NEWS RELEASE

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
1520 H STREET, NORTHWEST · WASHINGTON 25, D. C.
TELEPHONES: DUDLEY 2-6325 · EXECUTIVE 3-3260

FOR RELEASE: HOLD FOR RELEASE
UNTIL LAUNCHED
April 1960

NASA RELEASE NO. 60-152

TIROS SATELLITE
PAYLOAD

Today's launch from the Atlantic Missile Range will attempt to place a 270-pound meteorological satellite into a circular orbit, approximately 400 miles above the Earth. Primary satellite instrumentation consists of two TV cameras to take still photographs of the Earth's cloud cover. Launching vehicle will be a Thor-Able rocket.

The satellite looks like a giant pillbox, 42 inches in diameter and 19 inches high. Its appearance is somewhat unusual since its top and sides are almost completely covered by banks of solar cells -- over 9000 in all. Extending beneath the payload are four transmitting antennas. A single receiving antenna is located on the top.

Orbital inclination will be about 50 degrees to the equator. Traveling about 18,000 mph, the satellite will circle the Earth on an average of once every hour and one-half. The belt covered by the orbiting TIROS will extend from 50° N. Latitude to 50° S. Latitude. In the Western Hemisphere this covers an area between Montreal, Canada, and Santa Cruz, Argentina. During its approximately 1300 orbits during the next three month, TIROS will sweep over every point in this belt.

The payload is named TIROS (Television and Infra-Red Observation Satellite). There are two TIROS satellites scheduled this calendar year; however, this first is not equipped with the infra-red radiation sensors which map relative temperatures of the Earth's surface.

This U. S. launching is part of a long-range program designed to develop a satellite capability for providing world-wide meteorological information. The ultimate goal of the weatherman is to have world-wide meteorological observations at his finger tips for analysis. This would greatly assist him in preparing his weather forecasts. Such a wealth of data would lead to a more complete understanding of our weather and with this, perhaps some theories relating to weather control.

There are specific reasons for photographing cloud cover. Such pictures will provide meteorologists with cloud patterns indicating birth or existence of hurricanes, cyclones and other weather activity. It is hoped that these photos will provide meteorologists with more detailed information on individual cloud types over specific areas. Analysis of this data will assist meteorologists toward a better understanding of the causes of our weather.

The TIROS satellite is an experiment -- in itself it cannot be considered an operational weather system. Its useful lifetime is expected to be only about three months. However, if a meteorological satellite relaying weather data to Earth proves feasible, such a system consisting of several satellites providing coverage over the entire globe may one day be used on a continuing 24-hour basis.

This TIROS satellite, in addition to its TV cameras and associated equipment, contains beacon transmitters, attitude sensors, and telemetry circuits. Power is supplied by nickel-cadmium batteries charged by solar cells. Power output is expected to average about 19 watts.

There are two primary ground stations which can both command the satellite and receive photo data. These are located at Ft. Monmouth, N. J., and Kaena Point, Hawaii.

The two TIROS TV cameras differ in coverage and resolution. The side-angle camera, at 400 miles altitude, is designed to cover an area of cloud cover roughly 800 miles on a side. The narrow-angle camera will photograph a smaller area located within the wide-angle camera's view.

Identical except for lens equipment, the cameras are both the size of a water glass and use a ½-inch Vidicon tube especially designed for satellite use. Each camera consists of two parts: a Vidicon and a focal plane shutter which permits still pictures to be stored on the tube screen. An electron beam converts this stored picture into a TV-type electronic signal which can be transmitted to ground receivers.

These are some of the characteristics of the cameras--lens speed: wide angle - f/1.5, narrow angle - f/1.8; shutter speed: 1.5 millisec; lines per frame: 500; frames per second 1/2; video bandwidth: 62.5 kc.

Connected to each camera is a magnetic tape recorder. Out of ground station range, TIROS can record up to 32 photographs on the storage tape for later relay. Or, picture data from the cameras can by-pass the tape and be transmitted directly to the ground when within range of a station. The Mylar-base tape is 400 feet long and moves 50 inches per second during recording and playback. The two TV systems and their associated equipment operate independently of one another.

Photo data are transmitted from one camera at a time. Tape readout from each camera will take $3\frac{1}{2}$ minutes -- about 7 minutes for both. The satellite will be within transmission range of ground stations up to 12 minutes. This means that the satellite can transmit directly up to 4 minutes of photo data collected while within range of the acquisition station. Connected to each photo system is a 2-watt FM transmitter operating at a nominal frequency of 235.00 mc which will relay picture information on command to ground stations.

At the ground stations, pictures will be displayed on Kinescopes for immediate viewing and photographing. Photo data will also be sent to the U. S. Naval Photographic Interpretation Center for developing and processsing.

How will meteorologists identify photographs transmitted from the satellite? Based on tracking reports, the satellite's orbit will be accurately computed. Scientists connected with the project will be able to determine exactly where TIROS was or compute where it will be at any given time. Not only will the meteorologist know the geographical source of the photo, but he will know the directional orientation of the picture. Around the payload are nine solar cells. They measure the position of the satellite with respect to the sun. This information is transmitted to the ground stations with the TV transmission where it is processed by a computer to show which direction is north in each picture.

Two beacon transmitters, operating on 108.00 mc and 108.03 mc, both with a power output of 30 mw, will be used for tracking purposes. They can be modulated to provide information on satellite attitude, environmental conditions, and satellite equipment operation. For back-up purposes, both frequencies carry the same data. Each of the photo data acquisition stations are equipped with tracking antennas.

When the payload is separated from the third stage of the Thor-Able rocket, it will be spinning at about 136 rpm. Pictures taken from a vehicle with this rate of spin would be blurred. About 10 minutes after payload separation a de-spin mechanism will slow the revolutions to within camera operating limits -- 12 rpm. The de-spin mechanism consists of two weights attached to cables wound around the satellite. As the weights unwind they slow the rate of spin. They drop off automatically.

The satellite is expected to remain stable in its orbit as long as it maintains a minimum spin rate of 9 rpm. When spin slows to the minimum, control rockets will speed the satellite's rotation back to 12 rpm. There are three pair of these jets located around the baseplate of the TIROS. Each set can be used once. It is estimated that spin-up will be necessary only every 20 days. These jets are activated by command from the ground.

An infra-red detector within the payload senses the crossing of the Earth's horizon. This is transmitted to ground stations for processing to determine the attitude in space of the satellite's spin axis; it also can be used as a basis for computing spin rate.

Since TIROS is spin stabilized, it will not be "looking" at the Earth at all times. Based on tracking information, Ft. Monmouth and Kaena Point will program the cameras to take photographs only at those times when the satellite is viewing the Earth and when the area to be photographed is in sunlight. This is done by setting a timer. Program commands can be given as much as five hours in advance. Pictures taken while TIROS is out of range of the ground stations will be stored on tape for later relay. In the remote mode, the timer starts the camera, power, and transmitter functions. Each read-out wipes the tape clean. It immediately rewinds for its next recording.

When the satellite is within range of a station, ground command can directly turn on the cameras and photographs taken above the station will be relayed immediately below, by-passing the magnetic tape.

Ft. Monmouth will be the first to program the TV cameras. This will be done when TIROS sweeps over the East Coast of the U. S. for the first time, about an hour and one-half after launch. The New Jersey station will also read-out the first data after TIROS completes its second orbit, about three hours after launch.

The TIROS satellite is expected to operate for about three months. If its usefulness ends before this time, the tracking beacons can be commanded off.

Officials concerned with the development of the TIROS include:

Dr. Abe Silverstein, Director of Space Flight Programs, and Dr. Morris Tepper, Chief of Meteorological Satellite Programs, both from NASA headquarters; and William G. Stroud, Head of the Meteorology Branch of NASA's Goddard Space Flight Center and TIROS Project Manager.

Herb Butler, project manager for the U. S. Army Signal Research and Development Laboratory.

Vernon Landon and Edwin Goldberg, project managers for the Astro-Electronic Products Division of RCA.

HOLD FOR RELEASE
UNTIL LAUNCHED

No. 2
April 1960

TIROS

LAUNCHING VEHICLE

Consisting of three stages, the Thor-Able rocket stands over 90 feet tall and weighs more than 105,000 pounds at lift-off.

This is the third time the vehicle has been used as a satellite booster: The first for Explorer VI on August 7, 1959, and the second on an unsuccessful attempt to orbit Transit I on September 17, 1959. A Thor-Able sent Pioneer I 70,700 miles into space on October 11, 1958 and most recently on March 11, 1960, it boosted Pioneer V into a solar orbit.

Here is a breakdown of the stages and their functions:

First Stage:

Improved Thor, intermediate range ballistic missile, minus guidance and modified to receive additional stages.

Weight -- Over 100,000 lbs.

Thrust -- Approximately 150,000 lbs.

The liquid-fueled Thor propels the vehicle for about 160 seconds after launch. During this time, the rocket is controlled by roll and pitch programmers. During the latter part of first-stage boost, a plastic nose fairing covering the third stage and satellite is jettisoned and falls away. Upon separation, the Thor re-enters the atmosphere and disintegrates.

Second Stage:

Powered by a liquid-fueled engine, the second stage was adapted and modified from earlier Vanguard and Thor-Able rocket vehicles. At the top are six small rockets to spin-up the third stage. The second stage fires immediately after first stage separation.

Weight -- Over 4,000 lbs.

Thrust -- Approximately 7,500 lbs.

The second stage contains a highly accurate radio guidance system developed by Bell Telephone Laboratories and Western Electric Company. It is the same guidance used in the Titan ICBM. This stage propels the vehicle for about 100 seconds. At burnout, the spin rockets ignite causing the third stage and the payload to rotate at the rate of 136 revolutions per minute. The spin stabilizes the trajectory of the third stage and payload. About a second and a half after the spin rockets fire, second-stage is separated by a retro-rocket. The second stage then falls and burns up on entering the Earth's atmosphere.

Third Stage

A solid-propellant rocket, the third stage was adapted from the Vanguard and Able I rocket vehicles. It propels the payload to orbital velocity, about 18,000 mph.

Weight -- Over 500 lbs.

Thrust -- Approximately 3,000 lbs.

The third stage coasts for about 400 seconds before ignition. It goes into orbit still attached to the payload. Separation occurs about 25 minutes after third-stage burnout when a set of springs forces the third stage and payload apart. Burned out, the empty third-stage casing weighs about 50 pounds.

For the first time in any NASA satellite launch, the third stage carries a tracking beacon. It was designed by M.I.T.'s Lincoln Laboratory, Lexington, Mass., and built by Texas Instruments, Inc., Houston, Texas. Designed to be used with ground equipment at Lincoln Laboratory's Millstone Hill tracking facility in Westford, Mass., the beacon will assist in providing accurate trajectory information during launch. When the beacon receives a pulse from ground radar, it transmits a pulse back showing the location of the third stage. This system provides greater tracking range than "skin" tracking where radar signals are "echoed" back from the object in space.

HOLD FOR RELEASE
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No. 3
April 1960

TIROS

PROJECT PARTICIPANTS

To prepare the TIROS vehicle, place it in orbit, track it, and acquire, process and analyze data requires the cooperation and assistance of many Government agencies and industrial organizations.

The overall responsibility for the project rests with the National Aeronautics and Space Administration. The operational phase of the project is under the direction of NASA's Goddard Space Flight Center. Goddard will prepare the command programming which the ground stations will relay to the satellite. These programs will be based on information from NASA's Computing Center and the Meteorological Satellite Section of the U.S. Weather Bureau. Operational tracking will be provided by the Minitrack network.

The TIROS project was originally sponsored by the Advanced Research Projects Agency of the Department of Defense. In April 1959, the project was transferred to NASA.

The satellite and special ground station equipment was designed and constructed by RCA's Astro-Electronic Products Division, Princeton, N.J., under the technical supervision of the U.S. Army Signal Research and Development Laboratory, Ft. Monmouth, N.J.

The Air Force Ballistic Missile Division (ARDC), with its contractors, Space Technology Laboratories, Inc., and Douglas Aircraft Corp., was responsible for booster development and for mating booster and payload. In addition they provide launch services supported by the Air Force Missile Test Center which operates the Atlantic Missile Range.

There are two primary data receiving stations: one is operated by the Signal Corps at Ft. Monmouth; the other at Kaena Point, Hawii, by Lockheed Missile and Space Division and its consultant, Philco Corporation under contract to AFBMD, and under the technical supervision of the Signal Corps. Two back-up stations which cannot command the satellite but which can receive data are located at Cape Canaveral and Princeton, N.J.

Meteorologists in the Meteorological Satellite Section of the Weather Bureau will be responsible for the analysis and interpretation of cloud cover data. Assisting NASA and the Weather Bureau in weather data analysis will be the Air Force Cambridge Research Center, Allied Research Associates, Air Weather Service, Navy Research Weather Facility, and the Army Signal Corps. The U.S. Naval Photographic Interpretation Center will develop and process photographs before they are distributed for research purposes.

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FOR RELEASE: AFTER LAUNCH

APR 1 1960

NASA RELEASE NO. 60-158

FOURTH NASA TEST LAUNCH OF 100-FOOT SPHERE

The fourth in a continuing series of suborbital test launches of a 100-foot inflatable sphere was conducted by the National Aeronautics and Space Administration today from its Wallops Station, Virginia, launch site.

A test vehicle carrying the sphere was launched at 6:55 p.m., EST. It boosted the sphere to an altitude of about 200 miles. It traveled about 570 miles east across the Atlantic Ocean.

The experiment was part of a research and development program on:

- The mechanism for ejecting the sphere from its payload and inflating it in space.
- The third stage configuration of the Delta vehicle under development for NASA's launch vehicle program.

Similar launches were conducted from Wallops Station on October 28, 1959, January 16, 1960, and February 27, 1960, to test the 100-foot sphere NASA plans to place in orbit this spring for use as a passive communications satellite in Project Echo. The suborbital launches will be a continuing effort by the Langley Research Center, Hampton, Virginia, to explore and develop advanced inflatable structures as a follow-on program to the first Project Echo experiment.

Today's two-stage launch vehicle stood $32\frac{1}{2}$ feet high and weighed five and one-half tons at take-off. It produced an initial thrust of 130,000 pounds.

The first stage was one Thiokol Sergeant solid rocket with two Thiokol Recruit assist rockets to increase initial thrust. The second stage was an Allegany Ballistics Laboratory 248 solid rocket which will be the third stage of the Delta vehicle.

The 100-foot sphere was made of mylar plastic half a mil thick (half of one thousandth of an inch) coated with vapor deposited aluminum. The sphere itself weighed about 135 pounds. The aluminum provided a high degree of reflectivity of light and radio signals.

During the February 27 experiment, a radio signal transmitting voice from Bell Telephone Laboratories, Holmdel, N. J., was bounced off the sphere and received successfully at Massachusetts Institute of Technology station at Round Hill, Mass.

At launch today, the sphere was folded into a round magnesium container $26\frac{1}{2}$ inches in diameter. The complete payload package weighed about 190 pounds.

After ejection from the container, inflation of the sphere was begun by residual air inside it. Further inflation was accomplished by 30 pounds of sublimating powders carried in the sphere.

A telemetry transmitter on the second stage reported vehicle performance to ground stations at Wallops. The payload did not carry a beacon transmitter.

The 100-foot sphere was conceived by Langley's Space Vehicle Group headed by William J. O'Sullivan, Jr. The sphere and vehicle were developed by Langley's Applied Materials and Physics Division, Joseph A. Shortal, Chief. Project engineer was Norman L. Crabill of AMPD. Leonard Jaffe of NASA Headquarters is chief of communications satellite programs.

- END -

60-163

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

WASHINGTON 25, D. C.

HOLD FOR DELIVERY UNTIL PRESENTED
(Expected 10:00 a.m., April 4)

STATEMENT OF DR. T. KEITH GLENNAN
BEFORE THE HOUSE COMMITTEE ON SCIENCE AND ASTRONAUTICS
April 4, 1960

Gentlemen, I appreciate this opportunity to appear again before you and to discuss amendments to the statute which is our national charter for space exploration -- the National Aeronautics and Space Act of 1958. The bill before us is H.R. 9675. The record on it, which has been made during these hearings, is excellent. As your last witness and as one whose whole job is concerned with the administration of the Act, I want to be as candid and as helpful as I can in dealing with the issues.

Two things should be noted at the outset:

First, by way of background, the subject matter with which you and I deal is dynamic, fast-moving, and vital to this nation, We are concerned with getting ahead. We are concerned also with setting the right pace. In other words, we must run but not stumble. The very nature of our task demands coordination, cooperation, and decision. I think we can all agree on the importance of these objectives. To achieve them, we must not obscure the clear perception of our responsibilities, nor complicate the governmental structure in which we live, nor divert our efforts from fulfilling our primary mission.

Second, NASA was created twenty months ago by enactment of the National Aeronautics and Space Act of 1958. It was the product of a startled and somewhat anxious nation. Wisely, it created an agency with broad powers to develop and carry out a civilian program of aeronautical and space activities which would meet the needs of the nation. Cautiously, it erected an elaborate structure so that the machinery of government would be adequate and the attention of the highest authorities in the Executive Branch would be focused on space. I need not specify the many provisions of the Act which were intended to accomplish these objectives. I think we can all agree that the Act, as an initial effort, was a first-rate piece of legislation. But now, after these twenty months, all of us have learned from experience. It is appropriate, therefore, that we apply our experience to improving the Act under which we live. This we have done, and H.R. 9675 is the result.

In the President's own words, he recommends that the Act be amended "to clarify management responsibilities and to streamline organizational arrangements concerning the national program of space exploration."

Specifically, the clarification of responsibility proposed in H.R. 9675 affects subsections 102(b) and (c) under the title, "Declaration of Policy and Purpose," subsection 203(a) under the title, "Functions of the Administration," and a new section 309 entitled, "Coordination and Cooperation." The proposed streamlining of organization affects section 201, entitled the "National Aeronautics and Space Council," and section 204, entitled the "Civilian-Military Liaison Committee."

My purpose today is to consider with you, in the light of NASA's day-to-day experience during the past year and a half, the issues raised and some of the legislative suggestions made in the course of these hearings.

The first fundamental issue is whether there should be one or two governmental programs involving activities in space. There is no questioning the fact that today we have two organizations deeply engaged in such activities. The President, referring to the existing law, stated that the concept of a "single program embracing military as well as nonmilitary activities" should be eliminated. He said further, "In actual practice, a single civilian-military program does not exist and is, in fact, unattainable; and the statutory concept of such a program has caused confusion." As I see it, the President is seeking to make the statutory concepts fit the hard facts of life.

It has been argued that a single national program for space -- embracing both military and nonmilitary applications -- is not only attainable but also desirable. I have examined those arguments very closely, and I believe that basically they involve a failure to comprehend the variety, diversity, and breadth of potential human activity in this new realm. I believe that such views stem from a preoccupation with the areas of common technology involved in the military utilization of space and the civilian exploration of space for peaceful purposes. Further, legitimate concern with the possibility of duplication raises the spectres of waste and inefficiency which are assumed to follow from the existence of separate and divergent space programs. Finally, a single governmental program appears to offer the advantages of comprehensive, all-embracing planning and decision-making. These are the factors which appear to give rise to the suggestions that the military be given sole responsibility for a single national space program, or that NASA be reconstituted to conduct all research and development for activities in space, including military applications, possibly after the pattern of the Atomic Energy Act.

Now, I do not deny the desirability -- indeed, the enormous importance -- of the objectives of avoiding waste and achieving efficiency, nor do I criticize those who seek the virtues of comprehensiveness in planning and decision-making. I do not deny that there are large areas of science and technology which are common to both the military uses and the civilian uses of space. I will be in the front ranks with those who seek to identify and to make effective arrangements concerning areas of interest common to NASA, DOD, AEC, and other governmental agencies. I abhor bureaucratic jurisdictional disputations that follow from overlapping or uncoordinated missions.

Nevertheless, it is essential that the civilian mission of space exploration should not be confused with other governmental functions such as the national defense or the development of atomic energy. Although these functions are alike in their dependence upon science, their interest in research, and their need for hardware development, these facts should not cause us to lose sight of the unique mission of NASA.

The departments and agencies of the executive branch are organized along broad functional lines. They each have a mission in life. The Department of Defense is responsible for the military security of the nation; the Atomic Energy Commission is responsible for the development and exploitation of the new discoveries in nuclear physics. NASA should be just as clearly responsible for carrying out the nation's space exploration program.

Before turning to the organizational issues, let me make one more point with respect to the importance of an independent, civilian space exploration program. In my view, the fundamental wisdom of the National Aeronautics and Space Act of 1958 is enunciated in the very first sentence of the declaration of policy and purpose. I quote: "The Congress hereby declares that it is the policy of the United States that activities in space should be devoted to peaceful purposes for the benefit of all mankind."

I am convinced that space exploration is one of the most fruitful areas for agreement between ourselves and our principal international competitor. I foresee the practicality of arriving at mutually beneficial understandings on the peaceful utilization of space. It is essential, I believe, that the basic wisdom of the Act be preserved. Merging the civilian with the military uses of space is certainly not the way to do it.

The second fundamental issue is whether the law should prescribe a simple organization or a complex organization for space exploration. The plain fact is, our present overall organization is more complicated that it need be. Many witnesses before this Committee, in one way or another, have recognized this fact.

The President states "that it is no longer desirable to retain in the Act those provisions which impose duties of planning and detailed surveying upon the President," and he concludes that "the National Aeronautics and Space Council should be abolished, since its only function is to advise the President in the performance of those duties." He recognizes the necessity that "NASA and the Department of Defense advise, consult, and keep each other informed with respect to space activities within their respective jurisdictions," but he recommends that the Act "should not prescribe the specific means of doing so." He affirms that "the Act should contain safeguards against undesirable duplication. . . in developing the major tools of space exploration;" and while he proposes the elimination of the CMLC, he also proposes that "the Act be amended to provide that the President shall assign responsibility for the development of each new launch vehicle, regardless of its intended use, to either NASA or the Department of Defense."

As I see it, the President is seeking to increase the effectiveness of government through a simpler, more flexible organization. I hope also that we will avoid substituting some new organizational complexity in place of an old one.

I am aware that suggestions have been advanced which proclaim for themselves the virtues of simplicity. I am aware that other suggestions are based upon the assumption that the existing complexity of government itself requires an elaborate governmental organization for space exploration.

I have examined these suggestions with an open mind. They appear to me to be inspired by sincere desires to achieve program coordination among the various elements of the Executive Branch. They earnestly seek to accelerate and improve the workings of the decision-making machinery of government. They aim at mutually informed cooperation among agencies and departments in areas of common interest. They are motivated by laudable desires to avoid a vacuum in the administrative organization concerned with space. Thus, coordination, the improvement of decision-making, cooperation, and the filling of functional gaps -- these are the ends.

Let us look at the suggestions, other than those in H.R. 9675, for achieving these ends.

Operational coordination and accelerated decision-making are found by some in the idea of a czar for all the nation's space activities. Others would achieve these ends by assigning responsibility for military applications to NASA after the model of the Division of Military Application in the AEC, or possibly by subordinating NASA to the military. Mutually informed co-operation is found by others in the idea of liaison committees, perhaps after the model of the Military Liaison Committee in the AEC. Others find the avoidance of an administrative vacuum in retaining the Space Council and strengthening the Civilian-Military Liaison Committee in some form. These motives and these devices, when reduced to common terms, are all advanced to avoid waste and achieve efficiency -- in short, to get effective government for the conduct of space activities. The question is: will they?

Let us consider for the moment the idea of a space czar. The basic fact relevant to any evaluation of this idea is that only NASA and the Department of Defense have clear management and operational responsibilities in space. Unlike other agencies, such as the AEC, which contribute to space programs, only NASA and DOD actually utilize space -- that is, conduct activities in it in accordance with their respective missions. In this situation, the only justification for the creation of a space czar is that someone other than the President is needed to exercise the President's ultimate authority and power of decision over the Secretary of Defense and the Administrator of NASA. It must be assumed by those who advocate the creation of such an office in the White House that the President cannot, because of his multiple duties, give the nation's space activities the attention they deserve. I cannot accept this assumption, nor is there any basis for it in the experience of the last year and a half. I have had no difficulty in reaching the President and obtaining decisions.

Let us consider the idea of creating in NASA a Division of Military Application similar to that in the AEC. Atomic energy involves a single technology and the control of inherently dangerous physical ingredients. In space exploration, there is no basic material nor any single technology. The "monopoly" of the AEC cannot be likened to space. The fact is that NASA is not and never will be engaged in manufacturing hardware for the military departments according to their specifications. The relationship between DOD and the AEC's Division of Military Application is essentially that of user and supplier. This relationship must be differentiated from the relationship between NASA and DOD. In our case, NASA has in the past utilized launch vehicles previously developed by the military. In the future, the military may utilize launch vehicles developed by NASA. Nevertheless, the respective uses are and will be for different purposes. Accordingly, an organizational unit within NASA drawn along the lines of the Division of Military Application of the AEC is not a solution to the problems of coordination, decision-making, or cooperation.

Let us consider, too, the idea of liaison committees. The facts of life require liaison in the space business at all levels, formal and informal, involving both technical and administrative officials and covering basic policy, program definition, project selection, and operational detail. It is unrealistic and inefficient to compress such broad relationships into the confines of narrow channels. NASA's relationship to the DOD is not like that of the AEC. This relationship does not primarily involve a flow of requirements and specifications from DOD to NASA in order that NASA may perform functions of primary interest to DOD. The relationship between NASA and DOD does involve the constant, reciprocal exchange of information and advice at all levels. It follows that a liaison committee modeled upon the Military Liaison Committee of the AEC would not be appropriate.

Finally, let us look just briefly at the idea of subordinating the agency charged with the mission of space exploration to military control. I submit that this idea does violence to the basic national policy of utilizing space for peaceful purposes. It must therefore be rejected as a solution to the organizational problem.

I should like very much to be able to have each of you travel with me over the course of a major policy or program decision, from proposal to project, from concept to execution, and to observe for yourselves the unquestionable advantages of working within a simple framework connecting the Secretary of Defense and the Administrator of NASA to the President at the top. I cannot overemphasize the importance of a simple tri-angular structure. But, lest it be thought that the structure proposed in H.R. 9675 is too streamlined, let me say this: All of us recognize the need for cross fertilization among the sciences, and all of us recognize the need for bringing divergent views to bear upon the formulation of policy. All of us recognize the need to avoid functional gaps. However, one cannot be assured of bringing together the right people at the right time and under the right circumstances by creating, with the finality and formality of a statute, a czar, or a council, or a committee, or a division, which cuts across the functional lines of NASA and DOD, or which is not responsive to management.

During the past few months, as the tempo of space operations has increased, we have been very conscious at management levels in NASA and DOD of the existence of special areas requiring mutual consideration and joint planning. These areas are clearly identifiable. They include launch vehicles, launch pads, and support of

Project Mercury, among others. To date, the means of coordination, cooperation, and decision-making in such areas have been on an ad hoc basis. We have, however, now taken affirmative steps to create what may be called an "Aero-Space Activities Coordinating Board," with the Deputy Administrator of NASA and the Director of Defense Research and Engineering as the permanent co-chairmen. These men would be assisted by officials from each agency as may be appropriate for the problem at hand. You may recall that the Deputy Secretary of Defense, Mr. Douglas, when he appeared before this Committee, described the advantages of such a board. The board will be able to take effective action by virtue of the authority of the two co-chairmen.

Gentlemen, I respectfully submit that the present legislative need is the achievement of simplicity of organization and clarification of responsibilities for space activities. I strongly urge that this be accomplished by enactment of H.R. 9675.

Let me close with a single observation which inescapably pervades the whole space business. As one who has been able to observe first hand the education of the next generation in the USSR, I have no doubt that they are motivated by a desire to "beat America." All I can say to you is, I am motivated by a desire not to be beaten.

No. 60-163

NEWS RELEASE

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
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RELEASE NO. 60-164

FOR RELEASE: Released to wire services
April 4, 1960.

NASA AND ITALIAN SCIENTISTS TO CONDUCT
ATMOSPHERE STUDY

The National Aeronautics and Space Administration announced today that as a part of a cooperative program, it will conduct studies of the upper atmosphere with the Space Commission of the Italian National Research Council.

The program will be carried out with sounding rockets from an Italian launching site on the island of Sardinia. It is hoped the launchings may be coordinated with the International Rocket Week scheduled for September 1960.

According to the understanding reached by the two organizations, the Italian Space Commission will provide the rockets and launching facilities, and the NASA will furnish the instrumented payloads.

The NASA-Italian program is one of a series of cooperative international programs being developed by NASA.

All scientific data obtained in the course of this program will be made available to the world scientific community.

- END -

NEWS RELEASE

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FOR RELEASE: Wednesday April 6, 1960

FOR IMMEDIATE RELEASE

RELEASE No. 60-165

PIONEER V AT 3.5 MILLION MILES

Pioneer V whizzed by the 3.5-million-mile mark early today, apparently bent on proving that it will eventually outrace man's ability on the ground to communicate with it.

A 60-foot tracking antenna at South Point, Hawaii, is beginning to have trouble "reaching" Pioneer V. The 94.8-pound interplanetary satellite, however, is responding instantly to the commands of a 250-foot dish at Manchester, England. All experiments are working well.

Hawaii's problems illustrate the difficulties of deep space communication and how tracking performance is tied to the size of antennas. Manchester, transmitting commands to the probe at 500 watts, is having no difficulty turning the probe on and off. However, Hawaii, with its 60-foot dish transmitting at up to 16 times the output of the Manchester dish or 8,000 watts, must repeat its commands several times before the probe responds.

The tracking fraternity likens the operation to the focusing of a flashlight: a larger reflector is better able to concentrate its energy beam. The British dish, at 250 feet, is the largest in the Free World.

Meanwhile, Hawaii yesterday was forced to suspend operations for ground transmitter repairs but is expected to resume tracking operations this evening.

The probe is still transmitting to Earth on its 5-watt transmitter and will continue at the 5-watt level for several weeks as long as payload performace and signal quality remain high. Within probably the next six to eight weeks, an attempt will be made to turn on the probe's high-powered 150-watt transmitter.

All of this, of course, is predicated on the lifetime of the electronics. As yet, the 150-watt unit has not been tested in space. The feeling is why jeopardize the good quality of the 5-watt unit until absolutely necessary.

In the first 26 days of flight since its March 11 launch, Pioneer V has returned more than 60 hours of telemetry, averaging more than two hours a day.

Battery temperatures rose markedly yesterday when Hawaii dropped out. Due to battery overcharge, temperatures hit about 100 degrees F.--about 20 degrees above normal. When stations don't interrogate and thus drain the batteries, the charge builds and so does the temperature. This 100 degree temperature level, however, is not considered critical. It could rise to as much as

120 degrees F. before a charge-reducing circuit is designed to cut in and drain the battery charge overload. Should Hawaii ever drop out completely, the interrogation schedule could be adjusted so Manchester would "play" the probe for the usual two hours-plus daily. The temperature rise does demonstrate dramatically that the 4800 solar cells in the probe's four paddles are doing their job well, putting about 16 watts into the batteries constantly.

As of today, Pioneer V is gradually speeding up after falling off to a velocity low of about 5,360 miles per hour relative to the Earth. As it speeds up, gradually it will start pulling ahead of the Earth on its orbital track between Earth and Venus. Based on abundant and highly accurate initial tracking data, the probe's speed is known to within 1.5 feet per second and its position to within 300 miles.

A long-range projection of the Pioneer V trajectory shows that the probe and Earth will not come any closer than 16 million miles of each other before November 4, 1965. Meanwhile, the two will be farthest possible distance apart -- 183 million miles -- in September 1962.

Because of the eccentricity of the probe orbit, Earth and probe again will come within 15.6 million miles in April, 1966. From then on this pattern will repeat itself every 5.8 years with the distances slightly different each time.

A probe-Earth distance closer than the 1966 approach will not occur until 1989, when the two will come within two million miles of each other, according to present estimates.

The probe-to-Venus distance will grow less until September,1961, when the two will be separated by 22 million miles. At that time, the probe will be 150 million miles from Earth.

The probe and Venus will come within 15 million miles in November, 1963. In February, 1966, the probe will be roughly equidistant between Venus and Earth, about 20 million miles from Earth and 26 million miles from Venus. Greatest distance the probe will ever get from Venus is 160 million miles.

NEWS RELEASE

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
1520 H STREET, NORTHWEST · WASHINGTON 25, D. C.
TELEPHONES: DUDLEY 2-6325 · EXECUTIVE 3-3260

FOR RELEASE: April 7, 1960, 3:00 p.m.

RELEASE NO. 60-166

NASA AWARDS FIRST HONORARY SERVICE EMBLEMS

The National Aeronautics and Space Administration today awarded official honorary emblems for Government service to 312 employees at the NASA Headquarters. The awards were the first issued since NASA came into existence on October 1, 1958. Several thousand other NASA employees will be similarly recognized for their services at presentation ceremonies to be held at field installations later this month.

Heading the list of recipients at ceremonies held in Washington this afternoon was Dr. John F. Victory, Assistant to the Administrator, with over a half-century of service. Dr. Victory, the first employee of NASA's predecessor, the National Advisory Committee for Aeronautics, was cited for "50 years of leadership in this nation's aeronautical development". In presenting the award, Dr. T. Keith Glennan, Administrator, said,"...throughout this long career, he has selflessly devoted his time, his untiring energy and his outstanding ability to the Federal Government and its aeronautical programs....this certificate is awarded to one who truly merits the title 'public servant'".

Cited for more than 40 years of Federal service were Dr. Hugh L. Dryden, Deputy Administrator of NASA, 42 years, 13 with NACA and NASA; and Miss Catherine Wheeler, Assistant to the Director of Advanced Research Programs, 41 years of service, all with NACA and NASA.

Honored for 30 years of Government service were: Ira H. Abbott, Director of Advanced Research Programs; Mrs. Alexandrine Johnston, Administrative Assistant, Technical Information Division; Robert E. Littell, Assistant to the Director of Advanced Research Programs; Thomas T. Neill, Technical Assistant (Research Publications); Gerald D. O'Brien, Assistant General Counsel for Patent Matters; Richard V. Rhode, Assistant Director of Research for Structures and Operating Problems; Addison M. Rothrock, Scientist for Propulsion; Dr. Abe Silverstein, Director of Space Flight Programs; and Mrs. Virginia Walker, Management Analyst.

Other employees were cited as follows: 45 for 20 years of service; 111 for 15 years of service; 41 for 10 years of service; and 103 for one year of service. Among those receiving the award for one year's service was Dr. Glennan who was appointed Administrator on August 18, 1958.

- END -

NEWS RELEASE

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
1520 H STREET, NORTHWEST · WASHINGTON 25, D. C.
TELEPHONES: DUDLEY 2-6325 · EXECUTIVE 3-3260

FOR RELEASE: 10 a.m. EST
Friday
April 8, 1960

No. 60-167

Statement by T. Keith Glennan
Administrator

Tiros I, the U. S. experimental meteorological satellite, had been in orbit a full week at 6:40 a.m. EST today (Friday, April 8). During this period, in which Tiros had accomplished 101 trips around the world at an altitude of about 450 miles, hundreds of pictures have been transmitted electronically to ground receiving stations at the Research and Development Laboratory of the U. S. Army Signal Corps at Fort Monmouth, New Jersey and at the Kaena Point station in Hawaii, operated by Lockheed for the Air Force.

To date this meteorological experiment in space has performed exceedingly well. We have, in fact, been embarrassed by the wealth of photographic material which has been received. The plans whereby these photographs resulting from this experiment could be made available to the experts for study have had to be modified to speed up the processing of the film and preparation of prints.

Less than twelve hours after Tiros was launched from Cape Canaveral, NASA made available to the world four photographs taken by the so-called "low resolution" camera, and less than twenty-four hours later, two photographs taken by the "high resolution" camera were similarly made public.

In the brief period since then, possible confusions appear to have developed, respecting the purposes to be served by the Tiros I experiment. These confusions may have occurred because of the excitement within the National Aeronautics and Space Administration and the many other groups cooperating in this project. And confusions also, I am sure, because of the demands made by the press for materials at a rate that far exceeded our ability to satisfy. It is not every day that this kind of history is made.

To clear up possible misunderstandings, what follows is a brief account of Project Tiros and of the procedures to insure maximum beneficial results.

The description of the cameras and how the system was supposed to operate was stated at the time of launch as follows:-

"The two Tiros TV cameras differ in coverage and resolution. The wide-angle camera, at 400 miles altitude, is designed to cover an area of cloud cover roughly 800 miles on a side. The narrow-angle camera will photograph a smaller area located within a wide-angle camera's view. The narrow angle camera pictures cover 80 miles on a side.

"Identical except for lens equipment, the camera are both the size of a water glass and use a ½-inch Vidicon tube especially designed for satellite use. Each camera consists of two parts: a Vidicon and a focal plane shutter which permits still pictures to be stored on the tube screen. An electron beam converts this stored picture into a TV-type electronic signal which can be transmitted to ground receivers.

"These are some of the characteristics of the cameras--lens speed: wide angle - f/1.5, narrow angle - f/1.8; shutter speed: 1.5 millisec; lines per frame: 500; frames per second ½; video bandwidth: 62.5 kc.

"Connected to each camera is a magnetic tape recorder. Out of ground station range, Tiros can record up to 32 photographs on the storage tape for later relay. Or, picture data from the cameras can by-pass the tape and be transmitted directly to the ground when the satellite is within range of a station. The Mylar-base tape is 400 feet long and moves 50 inches per second during recording and playback. The two TV systems and their associated equipment operate independently of one another.

"Photo data are transmitted from one camera at a time. Tape readout from both cameras will take 3½ minutes. The satellite will be within transmission range of ground stations up to 12 minutes. This means that the satellite can transmit directly up to 4 minutes of photo data collected while within range of the acquisition station. Connected to each photo system is a 2-watt FM transmitter operated at a nominal frequency of 235.00 mc which will relay picture information on command to ground stations."

One piece of information NASA did not attempt to give, either in the material released at the time of launch or at the press conference held less than five hours afterwards, was the kind of detail that would be shown in the pictures produced by both cameras. The reasons for not doing so were, in my opinion, both understandable and valid: - In the first place, even the photographic experts have great difficulty in explaining in non-technical language the various factors that are involved in stating how detailed a picture may be. In the second place, we felt then, and still do, that the best way to describe the nature of the pictures is to make them public, for everyone...the experts and the non-experts...to see.

Another point on which there appears to have developed some misunderstanding is whether the photographs, from either the wide angle "low resolution" camera or the narrow angle "high resolution" camera, were classified.

As I indicated earlier, we were not sure what kind of information about cloud cover in various parts of the world our cameras would provide. The Tiros experiment was designed specifically, and solely, to obtain photographs of cloud formations around the world. The system was designed to give sufficient photographic sharpness, both from the wide angle and narrow angle cameras, to identify clouds which, because they reflect the sun, could be expected to show up well. The system was not intended to pick up detail on the earth, which shows up darkly in comparison to the clouds.

The only way we could test the working of the cameras before sending them into space...and this obviously was something less than a half-way measure...was to simulate on the ground the kind of picture we might expect Tiros to take. This experiment gave us evidence that we would be able to recognize clouds but little, if anything, more.

Every picture that Tiros has taken which has been processed to date is available for inspection by the press this morning at NASA Headquarters. There are several hundred of these pictures; they will be projected from the rolls of 35 mm film, the form in which they are "captured" on readout at the receiving stations.

These pictures all are from the Fort Monmouth station. The pictures from the Kaena Point receiving station have not yet arrived in Washington for processing. The first shipment was airmailed from Hawaii Wednesday. As soon as they have been processed, they, too, will be similarly available upon request - probably the first of the week.

In addition, prints of about a dozen of the wide-angle camera pictures, ones that show recognizable areas of the earth, are available. Prints of other pictures taken by the narrow-angle camera also are available.

One final point. NASA has repeatedly said that the Tiros I experiment is working successfully and well. That statement stands. However, since Saturday evening the clock timer which commands the photo storage tape recorder for the narrow angle camera has not been functioning properly. As a consequence, since then, the photographs taken by that camera have had to be limited to those taken upon direct command by either Fort Monmouth or Kaena Point and received directly (without going onto the tape recorder for storage) by either of those stations.

NEWS RELEASE

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
1520 H STREET, NORTHWEST · WASHINGTON 25, D. C.
TELEPHONES: DUDLEY 2-6325 · EXECUTIVE 3-3260

RELEASE NO. 60-169

FOR RELEASE: IMMEDIATELY
April 13, 1960

PROJECT MERCURY TRACKING STATION TO BE LOCATED IN MEXICO

The National Aeronautics and Space Administration announced today that Mexico and the United States jointly will establish a tracking station for Project Mercury, the manned satellite program. An agreement for this purpose was signed by the two nations yesterday, April 12, at 7 p.m., EST, in Mexico City.

The station will be located near the city of Guaymas on Mexico's West Coast. Its cost is estimated at about $2,250,000. Construction of the facility is scheduled to begin shortly.

The establishment of the Mexican facility adds another important link to the world-wide tracking network for Project Mercury. Ground stations will have the responsibility of accurately tracking the capsule in orbit and recording telemetered data on capsule performance and astronaut reactions, as well as maintaining communications with the astronaut.

Facilities at the Mexican tracking site will include tracking radar, telemetry receiving equipment, and radio equipment for direct voice communication with the astronaut. The telemetry equipment will be used for gathering data on the physiological condition of the astronaut, the condition of the life support system within the capsule, and for measurements on the capsule itself.

Present NASA schedule for the first orbital flight of an astronaut is in the latter part of 1961.

- END -

NEWS RELEASE
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
1520 H STREET, NORTHWEST · WASHINGTON 25, D. C.
TELEPHONES: DUDLEY 2-6325 · EXECUTIVE 3-3260

FOR RELEASE: THURSDAY 6 P.M., EST
April 21, 1960

RELEASE NO. 60-170
DU 2-6325

100-FOOT SPHERE LAUNCHING IN MAY

The attempt to launch a 100-foot inflatable sphere as a communications experiment is now scheduled for May 5, the National Aeronautics and Space Administration said today.

The date is being made public two weeks in advance of launch to allow volunteer project participants adequate time for preparations.

NASA announced plans for the experiment -- Project Echo -- in December (NASA Release No. 59-261 - 12/7/59), to give interested scientists sufficient notice to plan experiments involving the sphere.

The launch is planned for a time of day so that the inflatable sphere, made of highly reflective aluminum, will remain in continuous sunlight for about two weeks.

A three-stage Delta vehicle will attempt to inject the sphere into an orbit southeast from the Atlantic Missile Range, so that the orbital plane will be inclined about 48° from the equator. It will be aimed for an altitude of about 1,000 miles.

No radio tracking beacon will be attached to the sphere. The third stage of the launch vehicle will carry a transmitter which will broadcast at 108.06 MC for eight or ten days, the expected lifetime of its batteries.

Inflation of the balloon will be by residual air remaining in the folded sphere and by about 30 pounds of sublimating powders inside it. Water vapor will not be used.

-END-

NEWS RELEASE

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
1520 H STREET, NORTHWEST · WASHINGTON 25, D. C.
TELEPHONES: DUDLEY 2-6325 · EXECUTIVE 3-3260

FOR RELEASE: 5 p.m. Monday
April 18, 1960

No. 60-171

NASA Pushes Electric Rocket Development

The National Aeronautics and Space Administration today selected Avco and General Electric Co. to do engineering and preliminary development studies on an electric rocket engine.

Such engines show promise of one day powering spacecraft on interplanetary missions by supplying a small but steady amount of thrust (about a half a pound) over a period of months. The electric propulsion unit -- probably about the size of a standard thermos bottle -- would require an auxiliary electric-generating plant, in all likelihood a nuclear system such as SNAP 8 which is now entering development.

Avco and GE were amoung eight companies submitting proposals for a 30-kilowatt plasmajet engine. The two companies were selected for contract negotiations because their proposals offer "promising and different approaches to the problems this system presents," said T. Keith Glennan, NASA administrator.

Principle of the system calls for passing a propellant gas such as liquid hydrogen through an electric arc. The electricity heats the gas up to 4,000 degrees before the gas escapes through a rocket nozzle, producing thrust.

A major plasmajet problem is the development of electrodes capable of operating reliably for two months or more.

A plasmajet system will be three to four times more efficient than the most advanced chemical propulsion systems now in development.

A plasmajet appears ideally suited to operations in the weightless environment of space. It would be installed in a spacecraft and turned on when the craft is in orbit, to power it on a deep space mission. It is not intended for use as a launching vehicle from Earth because of thrust-to-weight ratio limitations.

"This is an area of advanced technology where many of the technical problems and optimum solutions are not defined by firm experimental evidence," Dr. Glennan said. "Thus we are experimenting with competitive approaches."

One of the basic differences between the two industry proposals selected is in the engine-cooling arrangement.

Assuming successful negotiations, the two companies will build and operate "breadboard" models of the engine in a one-year research program. If enough information is available at that time, a decision on development of a flight prototype may be made. Cost of the year-long investigation will be roughly $500,000 or about $250,000 to each company.

- END -

NEWS RELEASE

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
1520 H STREET, NORTHWEST · WASHINGTON 25, D. C.
TELEPHONES: DUDLEY 2-6325 · EXECUTIVE 3-3260

FOR RELEASE: IMMEDIATE
APRIL 19, 1960

NASA RELEASE NO. 60-172
DU 2-6325

NASA BEGINS NEGOTIATIONS FOR SUNFLOWER I

The National Aeronautics and Space Administration will negotiate with the TAPCO Group of Thompson-Ramo-Wooldridge, Cleveland, Ohio, to develop Sunflower I, a solar auxiliary power system for spacecraft.

The system will be designed to generate 3,000 watts of electrical power continually for a one-year period and has potential uses in satellites and in lunar or planetary spacecraft. It will weigh about 700 pounds and could fit within nose fairings which could be used on Centaur or Saturn launch vehicles.

The system consists of a large foldable solar collector, a boiler which uses solar energy to boil liquid mercury, a turbogenerator driven by the mercury vapor to produce electrical power, and a condensor-radiator to dissipate heat.

The petal-type solar collector is folded during launch and then unfolds to a diameter of about 32 feet. It is parabolic in shape similar to an automobile headlight reflector.

The other components are mounted on a tripod about 20 feet high in the center of the mirror topped by the boiler into which the reflector concentrates solar heat. Mercury, vaporized in the boiler, flows to the 30-pound turbogenerator which is a modified version of the SNAP-2 unit under development by the Atomic Energy Commission for use with a nuclear reactor heat source.

The large condensor-radiator converts the mercury vapor back into liquid by radiating heat into space and will be capable of operation in weightless conditions.

Also included in the Sunflower I system is a thermal energy storage unit which would permit continuous power output even when the spacecraft is in the earth's shadow.

For use in space, Sunflower I would require use of a sun orientation and attitude control device to point the solar collector toward the sun with less than one degree deviation.

The proposal selected as a basis for negotiation was one of 23 submitted by industry for development of Sunflower I. Thompson-Ramo-Wooldridge estimated that the cost of development of this system would be $4.9 million.

-END-

PRESENT PLANS FOR FUTURE SPACE DIETS

Presented
at
14th Annual Meeting
Research and Development Associates
Food and Container Institute, Inc.
April 20, 1960
Congress Hotel
Chicago, Illinois

Dr. Douglas L. Worf, Assistant Director
Technical Papers Program
Office for U. N. Conference
National Aeronautics and Space Administration

PRESENT PLANS FOR FUTURE SPACE DIETS

Those involved in planning space foods for future astronauts have been required to consider three difficult problem areas:

1. Space, lunar and planetary environments
2. Length of flight
3. Psychological aspects

The most severe environmental stress problem that will affect our selection of space diets for the astronaut is the unearthly gravity conditions to which he will be exposed. Gravitational conditions of less than 1 g are difficult, if not impossible, to simulate for long periods of time here on earth. Our input of information on the physiological and psychological problems pertaining to food ingestion in this environment must be extrapolated from short term weightless experiments in aircraft and from animal space flights such as with Able and Baker, with the Russian dog Laika until we have actually achieved manned space flight.

The worst problems facing food technologists in keeping the astronaut alive for prolonged periods in a weightless environment include:

1. Possibility of regurgitation or insufflation of volatiles, or particles of food and fluids.
2. Mechanics of eating.
3. Handling of wastes.
4. Storing and preparing foods.

Although all of the above may prove to be difficult the most severe from a physiological point of view, appears to be concerned with food lodging in the throat or entering the lungs by insufflation. A training period may enable the astronaut to prevent such occurrences. The consistency of food must be such as to minimize this hazard. Solid human wastes can be reduced by the selection of foods that are completely assimilated. The Armed Services have conducted tests which show that the use of such foods producing no solid wastes for periods of time up to a month, have no adverse physiological effects.

Survival of man in space with a degree of performance can be accomplished for a few days with adequate water and 100 grams of carbohydrate a day. At least it has been shown that this amount of food will reduce urine volume, prevent ketosis, and permit coordination. As little as 580 calories of carbohydrate with 4.5 grams of salt and a vitamin supplement will maintain the capacity for work for 12 days. Doubling the amount of calories will maintain capacity for work for 24 days without deterioration in pulmonary ventilation, oxygen debt, and pulse rate responses. If weight loss does not exceed 10% during this time performance capacity is well maintained.

Adding fat and protein to a ration at this calorie level appears to accomplish little, particularly with limited water.

Eight or nine hundred calories a day of carbohydrate plus water represents indeed a compromise with nutritional adequacy, but if the payload reduction must be taken from food, this would be a feasible consideration.

What will be the role of dehydrated foods in space diets? In manned space flight up to several months duration it is very probable that dehydrated foods will be used exclusively or a supplementary for the diets of future astronauts. In early manned space flight the regeneration of dehydrated foods will be carried out by water taken along for this purpose. As the flights become longer in duration the eight to nine pounds of water required for drinking and regenerating foods will be too expensive in terms of rocket engine and fuel weight. At this point we will be required to regenerate part, and eventually all, waste water. NASA recently initiated a project with the General Electric Company to refine a process for recovering potable water from condensed water vapor and other human waste water. Initial results reported on this process which uses a combined distillation and catalyzed pyrolysis are encouraging. Pure, potable water is obtained with relatively simple equipment. Solar energy collectors will supply the necessary heat required for this purification process.

Length of flight time and place of flight is important because this determines the fuel requirements. The more available payload expended for food the less available for equipment to carry out the scientific and technical objectives of the mission. The weight requirements for food, oxygen and water will limit man's usefulness in future space explorations unless, through research and development, we are able to write several new chapters on the technology of foods.

Suggested titles for these new chapters might be:

1. "Use of food as radiation, temperature and structural materials in space vehicles".

2. "Methods for processing human wastes to obtain man's input requirements for food, oxygen and water".

With regard to the first chapter we know by inspecting the composition of food that its rich hydrogen and carbon content make it an excellent shield against ionizing radiation. Without making an effort to go into detail regarding the radiation in space I would like to mention several types that are of concern in manned space flights of the future. These are:

1. Primary cosmic radiation.

2. Van Allen radiation belts around earth.

3. Solar flares.

Primary cosmic radiations have a wide range of energies. It is virtually impossible to shield against the higher energies. Fortunately, the dose that an astronaut would be expected to receive from this radiation is low (about .2 roetgen per year), so we are not concerned with stopping radiation of this type. The second radiation hazard in space is the trapped radiation belts around the earth discovered by Dr. James S. Van Allen. Although more needs to be learned about the configuration of these belts and the energy spectrum of protons and/or electrons, it is now believed that a moderate amount of shielding can stop this radiation. Food, with its hydrogenous content would make an effective shield. It has been suggested that in manned missions through these belts that the food can provide the necessary protective shield while on his return trip the solid and liquid human wastes generated may serve the same purpose equally well. The extent to which solar flares are a hazard is largely conjecture at this time because their frequency in space and characteristics are not well defined. It is probable, however, that the shielding used to protect the astronaut against the Van Allen trapped radiation will also be of the same order of magnitude needed to protect the astronaut from the radiation in solar flares.

On an equal weight basis food is a better shield against ionizing radiation than lead. The attached Figure gives the electron and proton penetration for elements of various atomic numbers. It is clear from this plot that food with its high hydrogen and carbon content will, on a weight basis, be a much more efficient shield than heavier elements. The use of a light material such as food would be particularly advantageous for shielding the astronaut against electrons since the secondary Bremsstrahlung produced by nuclear interractions is much less than denser materials. Little or no special fabrication will be required as long as the maximum amount of material is placed between the radiation source and the astronaut. It can be said with confidence that if his food and water supplies prove inadequate for protection against harmful ionizing radiation, it is unlikely that man will be used in future space explorations because of weight limitations of shielding.

The use of dehydrated food for a heat shield is promising because of the excellent thermal properties of its carbon content. Since there are a number of possible ways of designing heat shields this possible application will eventually require investigation by specialists in this field.

We will not be able to afford the luxury of wrapping foods in paper, plastic, or using metal containers. If a container is used it too must be edible. The reason for this becomes clear when we consider the fact that to place one pound of food on the moon requires 1000 pounds of rocket engine and fuel weight.

How else might we reduce the penalty in terms of payload weight for using man in long term space explorations? If we consider for a moment what the term "space garbage" implies we find that in part, at least, this can refer to literally tons of empty fuel containers and rocket engines that accompany the payload into space. What is the possibility that this tremendous container may actually be fabricated from food? If a polymer chemist studies the molecular composition of foods he finds many compounds that should be useful in formulating plastic materials. This part need not be oversold since most of us have been served so-called edible foods that might better have been used for building materials. If a determined effort is made in this direction a wide variety of edible structural materials might be formulated.

The factors that cause food to spoil here on earth, such as oxygen, moisture and microbial action are absent in space so we have the advantage of a favorable environment for food preservation. It is conceivable that these structures if made from food, could be placed in space or on the lunar surface and remain unchanged for years except perhaps for minor surface changes produced by U. V. Such structures could be sandwiched with a hard impervious surface having a softer pliable interior much like safety plate glass. Variety and palatibility could conceivably be designed into these edible plastic laminates. To carry out this development the food technologists would be required to understand the physical, chemical and temperature stresses to which the vehicle would be subjected.

With ample supply of solid food and means for regenerating most of his water requirements the astronauts' needs are fairly well taken care of except for oxygen. We are currently investigating several basic chemical processes for recovering oxygen from CO_2. Isomet, Inc. has demonstrated this to be feasible by three independent chemical methods. Means should be available within four or five years of research and development to keep man supplied with food, oxygen and water for periods of time up to a year.

The second chapter on food technology that needs to be written is entitled "Compact device for regenerating oxygen, water and food from human wastes". A good beginning has been made in this direction as many of you know -- using algae in a photosynthetic gas exchanger. There are several laboratories in this country devoting considerable time and effort to develop a closed ecological system for space vehicles. All of these projects are in the initial experimental phases. In Figure 2 is shown the basic elements of this closed ecological system. Algae utilize all human wastes; urine, feces and CO_2 as food and artificial or solar light as energy for the photosynthetic process. The algae during their growth process expire O_2 to supply the requirements of the astronaut. They are also a nutritious food although in terms of taste and acceptability much remains to be desired.

Development of a compact device should theoretically be possible although at least five years of intensive effort are anticipated before this objective is realized. Major problems to be solved are to:

1. Assure necessary energy to cells for their photosynthesis.

2. Achieve maximum growth rate under space environment.

3. Assure adequate gas exchange (CO_2 and O_2) under subgravity.

4. Achieve optimum growth of algae using human wastes with a minimum of processing.

5. Demonstrate long term high reproduction rate of algae.

6. Assess effects of ionizing radiation on growth rate of algae.

7. Improve taste.

8. Make long term evaluation on digestive processes.

With the tremendous world-wide interest in algae as a food source it can be assumed that significant progress will be made on many of these problems. Japan, for example, has a very active research program. Through the National Aeronautics and Space Administration's Office of International Programs and the Office of Science, State Department, we have made preliminary steps to cooperate with Japanese scientists to pool our knowledge and research potential in this area. The Japanese are doing particularly significant work on the problem of digestibility of algae. They have been successful in removing the hard indigestible cell membrane which has been the main problem in converting raw algae into digestible foodstuffs. Much more can and should be done to make this potential food palatable and digestible.

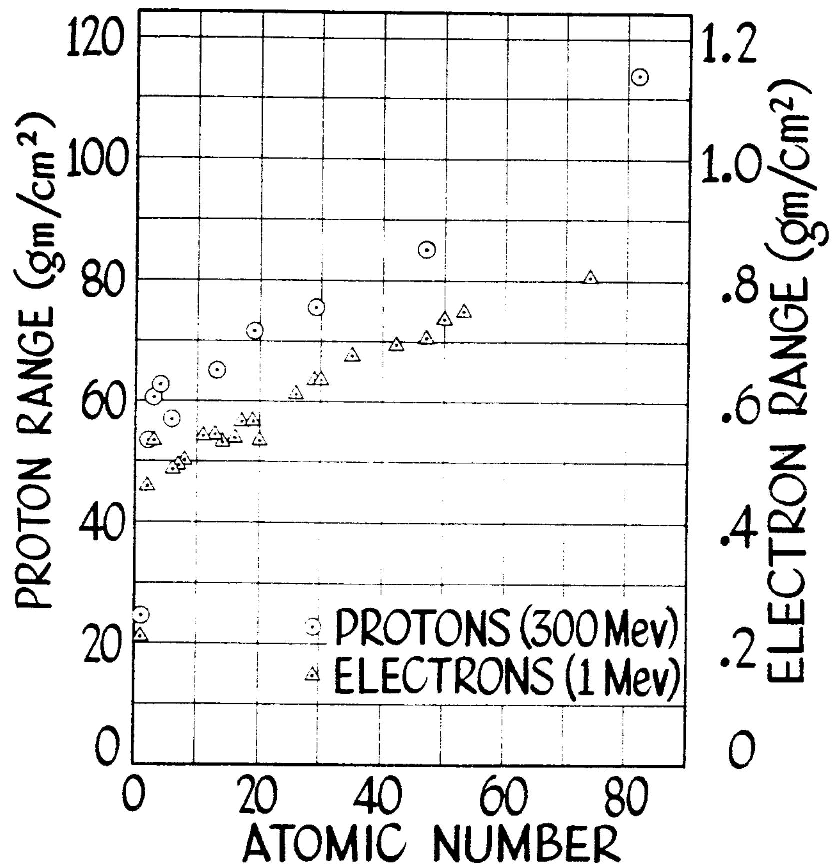
This brings us to the third problem area - psychological aspects. This refers mainly to food acceptance. Even under the most favorable circumstances food acceptance is a problem. How many of us quickly tire of a single restaurant? Service, quality, variety, appearance of surroundings and our companions influence the acceptability of foods. What then, will the unique set of circumstances of fear, isolation, weightlessness and cramped quarters have upon the acceptance of food by the astronaut? We have learned from Dr. David Simons high altitude balloon flight that certain foods regarded as very tasteful on earth become virtually unacceptable under the stressful conditions he experienced. As we obtain experience, first in short term manned space flights as in Project Mercury, then in progressively longer flights we should learn much more about the basic physiology of food metabolism and the effect of various stresses, psychological and physical, upon the acceptability of foods by man.

In summarizing what I have been trying to say, I feel certain that those of you involved in food technology face some of the most severe problems that have been encountered in providing the astronaut with a safe diet with little or no penalty to the useful payload. Whether man has a significant role in future space explorations may well depend upon technologists and scientists such as yourselves to solve these problems.

The suggestions of Dr. Freeman Quimby, Chief, Life Sciences Division, Army Research Office, in the preparation of this paper, are appreciated.

FIGURE I

PROTON AND ELECTRON RANGE VS. ATOMIC NUMBER



Address by

Richard E. Horner
Associate Administrator
National Aeronautics and Space Administration

Presented at

Seventh Annual Convention

The Society of Technical Writers and Editors

Meeting Jointly with

The Technical Publishing Society

Chicago, Illinois April 21-22, 1960

Richard E. Horner

FOR RELEASE
Thursday, April 21, 1960
ON PRESENTATION

Mr. Chairman, Distinguished Guests, Ladies and Gentlemen:

I am grateful for the compliment of your invitation to be with you this morning and to appear in this spot in the proceedings of your Convention.

When we were children I am sure that we each enjoyed the inevitable exposure to the fables of Aesop. It is difficult to imagine that a child could grow to adulthood without the advantage of learning the simple and purposeful lessons that these writings have been teaching for so many generations. Perhaps because of their simplicity and a matching impedance in my mental processes, I have been particularly reminded of one of these stories in the past eighteen months. It is not merely coincidence in this case that these have been the first eighteen months of existence of the National Aeronautics and Space Administration. The story I refer to, of course, deals with a man, his boy, and donkey as they proceed along a country road to the village. In response to the comments of many bystanders that they pass, they find themselves traveling in all possible combinations of riding and walking. First, with each of the three on foot. Second, with the boy riding the donkey, because he is the youngest. Then, the man riding because he is the oldest, and the boy walking. Next, with both the man and the boy riding the donkey. And finally they accept the ludicrous suggestion that the man and boy should walk and carry the donkey.

Recognizing the risk of suggesting the analogy, I can't but occasionally feel a kinship to these travelers in that the ceaseless stream of well-intended advice concerning the design and the prosecution of the nation's space program sometimes seems to be quite contradictory. We never permit ourselves overly critical assessments of such advice, however, because regardless of whether or not it is opportune to take advantage of its substance, it is a clear indication of the widespread interest in our efforts, and in this we are encouraged.

Indeed, those of us who are close to the day-to-day management problems of our nation's space program are convinced of one thing above all else--its long term health and support as a publicly financed endeavor is dependent to a large degree on a significant increase--yes, I might say, an unprecedented improvement in public understanding. One of the results of the technological revolution that has influenced our society so greatly in the past few decades is the ever-increasing divergence between the sum of information with which the average individual can claim familiarity and the total fund of information that is available on any given subject. When we consider the space program, even that fraction of the total information existing which impinges on the daily life of the individual is becoming more and more difficult to comprehend. Because of the very nature of the space program--the investments required, the motivations which drive it, and the results which can be expected--one can see that it is important to replace with knowledge and understanding the current confusion of the uninformed. As members of the technical press, yours is a serious and challenging responsibility. I have no question that you possess the capability and the will to meet this challenge. This you have already demonstrated.

We are also very much aware of the fact that your task can be made much easier and the results more satisfying to all of us if you are provided, by the full cooperation of those of us in Government, with the raw material of information sources. We have, therefore, adopted a policy of openness with the information we possess and seek at all times to be as frank and candid as we possibly can and still serve as responsible custodians of the public trust with which we have been charged.

Of course, it is necessary to recognize that ours is a program of research and development. Many of the problems we have, and many of the questions that we are asked, simply do not have categorically correct answers. Questions of judgment are most frequently involved; and, being human, you can be sure that we will commit our share of errors in judgment. When this proves to be the case, our only recourse is to correct our mistakes as best we can,relying on the understanding of our monitors--an understanding which can only be expected in the presence of full and complete information.

I hope that in the time allotted to me this morning I will be able to add in some way to our savings account of understanding as regards some of the important facets of our program.

There is probably no single category of considerations which bears on the space program more importantly than those concerning the motivations for doing this work, motivations which are recognized and accepted by our society as a whole. A long list of such motivations can be formed but few of them are universally accepted, and a still lesser number can be really depended upon in the final analysis to justify the size and scope of effort which has been initiated.

For example, many of us have debated from time to time the driving urge of man's curiosity. This is the undeniable force which explored the most remote regions on the surface of the earth. A variation of this force, in a more restricted sense, is the oft stated need for the advancement of science. The aesthetic values of learning more about the history of the universe, or the creation of the solar system, is a form of "exploring the West" for the scientists. Each of these incentives has produced tremendous efforts in the past by individuals or relatively small groups of individuals, and the results have frequently been commensurate with the expenditures. We cannot, however, avoid recognition of the fact that nations do not respond as individuals and it is inconceivable that even a majority of the American taxpayers today would agree to the expenditure of their substance in the amounts that are currently being invested simply for the gratification of adventure in new exploration.

But there are more tangible reasons for our activities in space. For example, it is virtually certain that practical application of space vehicles can be made for the benefit of the taxpayer who will pay the bill. It might be some time before such applications can be proven to be truly competitive on the basis of commercial economics. But even before that state of development is reached, it is likely that capabilities will be developed which will be of great value in our way of life and at the same time defy a direct cost evaluation by virtue of the fact of their unique qualities. One example of such a possible application is the meteorological service. The potential of providing to the meteorological physicist an almost simultaneous picture of the entire cloud cover of the world, the heat balance and its distribution, patterns of precipitation and the real time portrayal of the movement of these phenomena, is certainly a prospect upon which it is difficult to put a price tag since no one could possibly foresee accomplishing the same results in any way except through the use of space vehicles. The probability that such a prospect can be provided by this means was certainly given a tremendous boost by the launching on April first of the TIROS spacecraft. This experiment has transmitted back to the control stations on earth thousands of pictures of one of the important categories of information in weather analysis--that of cloud cover. There are tremendous tasks yet in front of us before an operational weather system can be expected, but the data obtained thus far is important in at least two respects. In the first place, it has demonstrated a technique which will be adequate, with some engineering refinements, to satisfy the need. In the second place, the pictures that have been furnished offer an excellent opportunity for analysts to assess the quality of data and the processing techniques on the ground, which will be necessary if timely use is to be made of the product from the space vehicle.

Meteorology is not the only promising area for the application of space vehicles. Within the next couple of weeks we expect to launch another experiment in satellite applications which will be of substantial interest. I refer to our first launching in Project ECHO. This involves the placing in orbit of a sphere 100 feet in diameter, which is made of plastic with an aluminum coating. During the launch acceleration, this sphere will be folded up and contained in a smaller metal spherical case about 28 inches in diameter. When it attains orbital velocity the shell opens up and the larger sphere is inflated by virtue of the residual air in the folds. In addition, a crystalline compound which sublimates slowly in the hard vacuum of space provides a continuous gas source to keep the sphere extended even though it cannot be made gas-proof. The rate of gas leakage will also increase with time, as collisions with meteors make holes in the surface.

The primary purpose of the experiment is to test the technique of bouncing radio signals from one point on the earth's surface off the aluminum balloon to another point at a great distance. We have, for example, provided high powered radio transmitters and receivers at the Goldstone Tracking Center in the California desert and, with the cooperation of the Bell Telephone Laboratories, a similar installation at Holmdel, New Jersey. When the inflated satellite is in a favorable position, we expect these two facilities to be able to talk to each other using portions of the frequency spectrum which can ordinarily be used only in line of sight communication schemes. The characteristics and timing of the experiment have also been disseminated throughout the world, and we have indications that scientists in many foreign countries intend to conduct local communications tests.

I might say, parenthetically, that this experiment will have, in some respects, a more spectacular appeal even than its utility in a communications system. At dawn and dusk, it will provide a reflector for sunlight which most of the peoples of the world will be able to see as a star somewhat brighter than Venus, moving across the heavens at some 18,000 miles per hour.

It is also necessary to add here that one of our greatest uncertainties in the operation of this experiment is the determination of the length of time it will remain in orbit. Because of the very low density of the inflated sphere, we anticipate that the orbit will decay much faster than has been the case with other experiments; and even before it re-enters the earth's atmosphere it might lose most of its reflective qualities as the result of collapsing after losing internal pressure.

A qualitative assessment of these effects has led us to believe that the useful life might vary from a few days to a few weeks. A realistic answer to this kind of question, however, must wait until we have had some experience, and we expect that one of the notable scientific products might very well be a better measurement of atmospheric drag at altitudes ranging from 800 miles down to the denser atmosphere.

The motivations supporting our space program which lie beyond the promise of satisfying a useful purpose in our everyday lives are the more demanding needs of national prestige and military requirements. Let me treat the latter briefly by saying that we are cooperating very closely with the Department of Defense. We use the products of their very comprehensive research and development programs, and I have no doubt that they will use the results of our activities. We have established an excellent rapport between the two organizations.

In the fulfillment of our national needs for demonstrating the virility and viability of our particular system of government, the NASA plays an even more important role. The combination of circumstances resulting from the determination by our Congress that space exploration should be for peaceful purposes and for the benefit of all mankind, together with the determination of the Department of Defense that no immediate military requirement demands the development of larger space vehicles, has placed our organization squarely on the firing line in the weight-lifting competition with the U.S.S.R. It has been quite apparent that this competition has been the most influential of all the factors to be considered in determining the overall scope of our efforts. I would not want to leave the idea that we are developing bigger rocket engines and bigger launch vehicles for the single purpose of exceeding the performance of the Russians. But it is our present international position which has urged us onward in prosecuting these developments at the current rate. Thus we are concentrating on the development of a stable of four different models of launch vehicles. And during the next year almost half of our total resources will go into this effort.

We have just begun the first experimental launchings of the SCOUT vehicle. This is a small solid propellant four-stage device which will permit us to put in a low earth orbit an instrument package of about 200 pounds. It will be cheaper and more flexible in its use than has been the case with any of the liquid rocket vehicles that we have used to date. In approximately one year we expect to make our first operation with the Atlas-Agena. This is a vehicle which, while developed in the Department of Defense, will be adapted to the uses of our program quite extensively. The Atlas-Agena will provide us substantially the weight-lifting capability that has been demonstrated thus far by the U.S.S.R. In 1962, we hope to be using the Atlas-Centaur, a vehicle which uses liquid hydrogen and liquid oxygen in its upper stage, and with these high energy propellants provides an orbital capability for approximately 10,000 pounds. And in the 1964 time period, the Saturn vehicle will become operational, with an early capability of 25,000 pounds in a low earth orbit and growing to double that capacity with the further development of the upper stages in the latter part of this decade. These will be the four work horses of our space program for the next ten years--the numbers of different kinds of vehicles are being reduced in order to improve the reliability of each by increasing the number of times it is used.

Having established this schedule for vehicle development--which I believe holds good promise for matching the performance of the U.S.S.R. and certainly provides the lifting capability to meet our requirements in this time period--we must proceed with an energetic program of spacecraft development which will make good use of this capacity. I am strongly convinced that the fascination of the competition with the U.S.S.R. in the rocket development introduces the danger that we might not focus quickly enough nor with the necessary vigor and tenacity on the problems of spacecraft development. I am sure that no one wants to be lifting tons of dead weight into space, but I am equally sure that there is, today, little appreciation for the tremendous development task which is involved in making proper use of the lifting capability we are developing. Some of our spacecraft of the future will approach the size and complexity of small modern high performance aircraft. When one considers that we propose to launch an average of two spacecraft each month for the next ten years, it can be seen that a level of development is required which exceeds any performance that has been demonstrated to date.

It almost goes without saying that such a development program will be expensive. In the course of its first two years of operation, the NASA will have more than doubled its annual expenditure rate. It is clear that if the proposed program is to be carried out, further increases are inevitable. It is also clear that if gross inefficiencies are to be avoided, the program must be supported consistently by the nation--a support which can only be expected from a well-informed public.

To many of us, the fact that the rate and scale of our present effort is strongly influenced by the international competition is a real danger, not because we do not recognize the importance of national prestige, but because support which is dependent upon our relative position in space achievements with the U.S.S.R. tends to be fickle and too much a function of their activity factor--a factor over which we have no control. As you might imagine, such support complicates our planning, might very well become oscillatory, and thus lead to the inefficiencies of stop-and-go development. Perhaps we are needlessly concerned, since our competition to date has shown no lack of either capability or desire to keep the pressure on us. But it is at least partly because of this concern that we have insisted upon the formulation of our program on a broad and diverse base which seems to best suit the needs of our society as well as its capabilities.

It seems likely to me that perhaps in the long term one of the most rewarding products of our space experimentation will be the overall augmentation that it provides to our nation's technology. The many unique skills and techniques that are being developed in response to the demanding needs of the space environment--the vibration, the noise, and the accelerations of rocket vehicle operations, and the rigorous tolerances of long-time automated operation--will have their impact on many areas of our technically sophisticated and highly mechanized way of life.

I recently enjoyed the opportunity to talk at some length with Dr. A. W. Lines, the Senior Superintendent for Research, of the Guided Weapons Department of the Royal Aircraft Establishment in the United Kingdom. Mr. Lines had just completed a month long tour of American industry and laboratories. He expressed himself as being astounded at the broad scientific and technical program which was being supported as a result of this nation's space and defense effort. Speaking in superlatives, he said that he felt he could emphasize his assessment of the work he had observed in no better way than to report his own concern at the problem he faced in identifying an area of work where his country could make a suitable contribution. He also was certain from his widespread visits that few, if any, Americans really appreciated the diversity of ultimate applications which would flow from this program.

There can be little question that the space program is a powerful influence on the continuation of the technological revolution which we have seen developing around us during our lifetime. It may be that its influences are in some ways peculiarly advantageous to the United States, since the only other major participant in space experimentation is somewhat limited by the current status of its society in accepting the technical innovation that naturally flows from the effort. It is also possible that should the day come that we all so strongly hope for--the day of disarmament agreement--the program of space exploration may become an even more important influence in support of our advanced technology.

Thus, I hope that you will each agree with me. There is the promise--indeed I might say the certainty--of real and lasting benefits to each of us and to our nation in carrying out the program of space exploration and space applications which we have planned. This is a program of many and diverse activities. Hopefully, it will bring such accomplishments as a man launched into space on a ballistic flight during the current year, and in orbit around the world next year; continued meteorological and communications experiments until operational systems can be established a few years from now; continuous exploration of the moon and the near earth space, leading to manned flight around the moon in the latter years of this decade; and a progressively more energetic program of exploration of the near planets.

The program will be much in the news, and I am sure that the widespread understanding of its objectives and its rewards will continue to grow. This will occur in large measure as the result of your activities, and we do appreciate your efforts in this respect. May I again pledge our cooperation to you in your work. I know that it benefits all of us.

NASA Release No. 60-173

1. Gas-light contacting chamber
2. O_2 absorption tanks
3. Nutrient supply tanks
4. Gas-holding or surge tanks
5. Air blower for gas recirculation

FIGURE 2

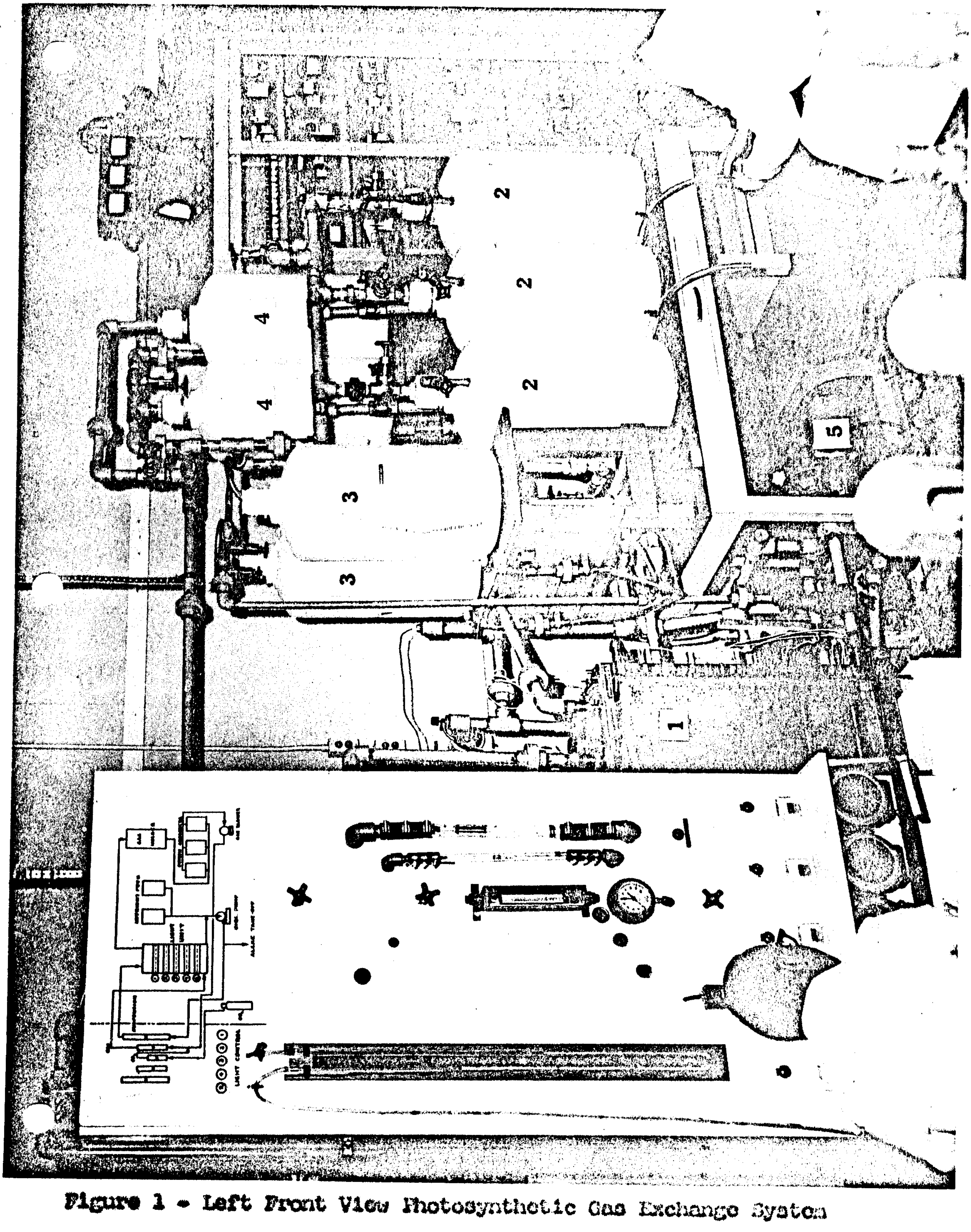


Figure 1 - Left Front View Photosynthetic Gas Exchange System

PROSPECTS FOR SPACE TRAVEL

Hugh L. Dryden
Deputy Administrator
National Aeronautics and Space Administration

(The Penrose Lecture before the American Philosophical Society, Philadelphia, Pa., April 21, 1960)

CONTENTS

Introduction

For centuries man's travels were confined to the surface of the earth. Then at the turn of the present century the Wright Brothers moved from the ground into the air. Man soon attained the freedom of the birds and in a half century far surpassed their performance. Today he spans the oceans and continents in modern jet transports. Soon he will be able to pace the sun in its apparent travel from east to west.

In ancient times before written records, long before the attainment of the first flight of man in an airplane, some expressed their aspirations in tale and legend. Others sought imaginative expression of the primitive science and technology of their day in the attempted invention of flying machines. Success was delayed until the necessary broader base knowledge of air flow, propulsion, materials and structural design had been established and the internal combustion engine had been invented and constructed.

Before the first flight there were differences of opinion with respect to the prospects of early success and, even after the first flight, estimates of the rate of progress varied widely. Wilbur Wright himself stated in 1908[1]: "I confess that, in 1901, I said to my brother Orville that men would not fly for fifty years. Two years later we ourselves were making flights . . . . But it is not really necessary to look too far into the future; we see enough already to be certain that it will be magnificent." In the same year Simon Newcomb[2] remarked, "The writer cannot see how anyone who carefully weighs all that he has said can avoid the conclusion that the era when we shall take the flyer as we now take the train belongs to dreamland."

On October 4th, 1957, Russian scientists launched a man-made moon for the first time in orbit around the earth, heralding the fast approaching realization of a second age-old dream of man to travel into interplanetary space. This year man will venture briefly into nearby space in the X-15 research airplane and in the Redstone ballistic flights of Project Mercury. Hopefully in 1961 the first orbital flights of a manned satellite will mark the step in space travel corresponding to the flight of the first airplane.

Historical Notes[3]

Interest in space travel has ebbed and flowed through the centuries in synchronism with the state of development of knowledge of outer space. Interest in outer space probably began among the forerunners of astronomers in ancient lands. Exploration was by visual observation of the sky by day and by night. The regularities of apparent motion were first noted, and the sky became the earliest clock and almanac. The sun, moon and planets were objects of worship. The notion of travel in space could not arise until the concept of the celestial bodies as other worlds existed.

The first cycle of interest in space travel occurred in ancient Greece as a result of the work of Greek astronomers who abandoned the flat earth concept. One of the great astronomers of the second century B. C. was Hipparchus who invented what we now call the Ptolemaic system. Ptolemaeus further developed and expanded the work of Hipparchus in the second century A. D. Influenced by these developments Plutarch[4] concluded that the moon is much like the earth, but smaller, inhabited not by people but by "demons," who occasionally visit the earth. In the year 160 A. D. the Greek writer Lucian wrote the first novel[5] of a voyage to the moon. The mode of travel was somewhat fortuitous, a ship in the fearsome Atlantic Ocean being caught in a whirlwind and lifted to the moon.

Interest then disappeared through the fourteen centuries during which the authorities of the Christian Church, following Aristotle, opposed belief in the existence of other worlds. Then came Nicolaus Copernicus with revolutionary ideas in astronomy.[6] The telescope was invented in Holland, probably by Hans Lippershey in 1608. Johannes Kepler[7] by analyzing the observations of Mars made by Tycho Brahe established that the planets move in elliptical orbits around the sun rather than in epicycles whose centers moved in circular orbits. Finally Galileo[8] observed the disks of the planets with a telescope made by himself after receiving some information about Lippershey's instrument. These new developments in astronomy inaugurated a new cycle of interest and speculation about space travel to other worlds.

Kepler himself wrote a fantasy[9] about travel to the moon which was published after his death. Travel of man was accomplished by the aid of demons, who, unable to withstand the light of the sun, travel within the shadow of the earth when it touches the moon in an eclipse. The first journey to the moon to be described in English literature is found in a book by Bishop Francis Godwin[10] printed in 1638. The hero, Domingo Gonsales, built an "Engine" to fly through the air which unexpectedly proved capable of taking him to the moon. The motive power was furnished by wild Swans called Gansas who were taught many "trickes." The development of the "Engine" is described in the following terms:

"Having prevailed thus farre, I began to cast in my head how I might doe to joyne a number of them together in bearing of some great burthen: which if I could bring to passe, I might enable a man to fly and be carried in the ayre, to some certaine place safe and without hurt. In this cogitation having much laboured my wits, and made some triall, I found by experience, that if many were put to the bearing of one great burthen, by reason it was not possible all of them should rise together just in one instant, the first that raised himselfe upon his wings finding himselfe stayed by a weight heavier then hee could move or stirre, would by an by give over, as also would the second, third, and all the rest. I devised (therefore) at last a meanes how each of them might rise carrying but his owne proportion of weight only, and it was thus.

"I fastned about every one of my Gansa's a little pulley of Corke, and putting a string through it of meetly length, I fastened the one end thereof unto a blocke almost of eight Pound weight, unto the other end of the string I tied a poyse weighing some two Pound, which being done, and causing the signall to be erected, they presently rose all (being 4 in number,) and carried away my blocke unto the place appointed. This falling out according to my hope and desire, I made proofe afterwards, but using the held of 2. or 3. birds more, in a Lamb, whose happinesse I much envied, that he should be the first living creature to take possession of such a device.

"At last after divers tryalls I was surprised with a great longing, to cause my selfe to be carried in the like sort. .... So upon a time having provided all things necessary, I placed my selfe with all my trinckets, upon the top of a rocke at the Rivers mouth, and putting my selfe at full Sea upon an Engine (the description whereof ensueth) I caused Diego to advance his Signall: whereupon my Birds presently arose, 25 in number, and carried mee over lustily to the other rocke on the other side, being about a Quarter of a league."

There appeared in 1640 the third edition of a book by Bishop John Wilkins[11] in which the hope was expressed that science would soon discover the means to travel to the moon. About a decade later Cyrano de Bergerac[12] wrote about travel to the moon. Different travelers used different means of transportation; (1) bottles filled with dew, a substance which every morning was believed to disappear by being drawn toward the sky; (2) lodestones thrown upward continuously to propel an iron car upward; and (3), surprisingly enough, powder rockets.

With the further growth of astronomical knowledge, distances to celestial objects became more accurately known, and the distinction between travel through the atmosphere and travel through the vacuum of space was finally understood. Space travel then seemed impossible, and interest in it was replaced by interest in communication with the inhabitants of other worlds. The famous German mathematician and physicist, Karl Friedrich Gauss[13] in the first half of the 19th century proposed to use the language of mathematics by drawing the geometrical figure, consisting of a triangle and three squares which demonstrate the theorem of Pythagoras, on the gigantic blackboard of the Siberian tundra. The "lines" of the figure were to be composed of strips of dark pine forest, each line being ten miles wide. An alternate scheme was proposed by the astronomer Littrow[14] in which the Sahara desert was to constitute the background and the lines were to be made by wide trenches filled with kerosene which was to be ignited to produce lines of fire.

In the latter half of the 19th century, further observations of Venus and Mars with improved telescopes and advances in the technology of ballistics stimulated novelists to write of space travel to Mars and Venus as well as to the moon. In 1865 there appeared Achille Eyraud's Voyage à Vénus[15] and Jules Verne's De la terre à la lune[16] and two years later Verne's Autour de la lune.[17] Then at the turn of the century the imaginative science fiction novels of H. G. Wells[18] closed this period of interest in space travel.

There followed again an ebb of public interest in space travel lasting for four decades. However beneath the surface there began to emerge inventions, scientific knowledge, and practical developments which have resulted in present national activities and revived public interest in space travel. How far below the surface these activities were may be judged from the fact that the Fourteenth Edition (1929) of the Encyclopaedia Britannica does not contain the names of the Russian, K. E. Tsiolkovskii or the Rumanian, H. Oberth, now recognized as pioneers in the theory of the application of rockets to space travel. A brief paragraph on Rocket Propulsion states that "The pioneer work on the use of the exhaust of a rocket to propel a body was done by Prof. R. H. Goddard of Clark University, Worcester, Mass., who has studied the problem since 1909. In 1928 experiments were carried out on a rocket intended to travel into the rarefied upper air so as to obtain data as to its composition and condition. In 1918 Prof. Goddard, under the auspices of the Smithsonian Institution, published data supporting the practicability of a rocket flight to the moon."[19]

A major factor in our current position in space travel is the curious accident that the Versailles treaty with Germany at the end of the first World War failed to include rockets among the military weapons prohibited to Germany. As a result in 1929 the German Army began the development of rockets which eventually resulted in the large V-2 rocket first fired successfully on October 3, 1942 in test flight and on September 6, 1944 as a weapon. Rocket research in the United States began at the California Institute of Technology in 1936; the development of their first rocket began in 1944. The development of large rockets as weapons produced the presently used space boosters both in the U.S. and the U.S.S.R. The Jupiter, Redstone, Thor and Atlas missiles, including their guidance systems but not warheads, are essential components of current U.S. space vehicles.

U.S. interest in space began during the International Geophysical Year 1957-1958 when it was decided to develop a satellite vehicle under civilian direction without interfering with the missile program carried out under military auspices. The Vanguard launch vehicle was designed specifically as a satellite launch vehicle. Although the early launchings were unsuccessful, the second and third stage rockets are essential components of later space vehicles and the Minitrack stations are the backbone of our current satellite tracking system.

As is well known the U.S.S.R. launched the first satellite on October 4, 1957 using its well tested military rocket. Soon thereafter the U.S. Army was authorized to use the Redstone missile in conjunction with a cluster of solid propellant rockets developed by the Jet Propulsion Laboratory of the California Institute of Technology. The first attempt on January 31, 1958 to place Explorer I in orbit was successful.

Interest in space travel is now expressed by governmental authorities of both the U.S. and the U.S.S.R. In closing this brief historical account we may note that the first formal governmental action was the appointment in 1954 by the Presidium of the U.S.S.R. Academy of Sciences of the Interdepartmental Commission on Interplanetary Communications to "coordinate and direct all work concerned with solving the problem of mastering cosmic space." The nearest equivalent action in the U.S. was the passage of the National Aeronautics and Space Act in 1958.

Beginning of the Direct Exploration of Space

The direct exploration of space by means of unmanned vehicles traveling in space began on October 4, 1957 with the launching of Sputnik I by the U.S.S.R. In the intervening thirty months there have been launched successfully eighteen additional earth satellites which have yielded much scientific information about the space environment by radio telemetry of data to the ground. Two satellites were launched by the U.S.S.R. on November 3, 1957 and May 15, 1958. The U.S. has launched sixteen satellites, the first on January 31, 1958 and the most recent on April 16, 1960. Five were called Explorers, launched by Jupiter Cs in three cases, Thor-Able II in one, and Juno II in one. Three were Vanguards; five were Discoverers, launched by Thor-Agena As; one used an Atlas for the communications experiment, Project Score; one the meteorological satellite of Project Tiros, was launched by a Thor-Able IV; and one, the navigation satellite Transit, was launched by a Thor-Able Star.

Seven space probes have been launched since October 4, 1957, three by the U.S.S.R., four by the U.S. All of the U.S.S.R. space probes were directed toward the moon; one launched on January 2, 1959 passed within a few diameters of the moon and went into an orbit around the sun. The second, launched on September 12, 1959, hit the moon. The third, launched on October 4, 1959, passed close enough to take pictures of the far side of the moon and was deflected by the gravitational field of the moon to return toward the earth. The first U.S. space probe, launched on October 11, 1958 traveled to a distance of 70,700 miles; the second, launched on December 6, 1958 to 63,580 miles; while the third, launched on March 3, 1959 went into orbit around the sun, communication with it being maintained to a distance of 407,000 miles. The fourth was launched on March 11, 1960 inward toward the orbit of Venus and on April 18 was at a distance of a little more than five and a half million miles from the earth with data still being received by telemetry.

Each of the satellites and space probes has produced much information on various aspects of the space environment itself and of environmental conditions within space vehicles. Many of the missions have been directed toward scientific objectives relating to the earth and its atmosphere and ionosphere. To illustrate the types of information returned, we may consider the return from Sputnik II, Lunik III, Pioneer V, and Tiros I.

Sputnik II was launched into an elliptical orbit with initial perigee of 140 miles and initial apogee of 1038 miles inclined at 65 degrees to the equator. It carried the dog "Laika" for measurement of physiological reaction of an animal to space flight. Its instruments measured cosmic rays, solar ultraviolet and X-radiation. Temperatures and pressures within the satellite were measured. Significant solar influence on density in the upper atmosphere was noted from measurements of fluctuations in satellite drag which were directly correlated with solar activity. Cosmic ray counting rate increased with height, not understood at the time but later found to be associated with the Van Allen radiation belt discovered with the instruments in Explorer I.

Lunik III produced the first pictures of the far side of the moon. Lunik III demonstrated maneuverability in a large space craft, the successful storage of pictures on film and their later transmission back to earth. Apparently no further scientific data were obtained because of early failure of the power supply or transmission system.

The Pioneer V space probe, weighing 94.8 lbs., was accelerated to a velocity of 24,869 miles per hour in an orbit about the sun inclined inward toward the orbit of Venus. Its period is about 311 days. Its perihelion is about 74,700,000 miles which is about eighteen million miles closer to the sun than the orbit of the earth. Long-range projection of the trajectory forecasts that Pioneer V will be farthest from the earth -- 183 million miles -- in September 1962 and that the earth and probe will approach within 16 million miles in November 1965. Because of the eccentricity of the probe orbit, the probe again will come within 15.6 million miles in April 1966. A closer approach than this will not occur until 1989 when the two will come within two million miles of each other according to present estimates. The probe carries instruments to measure charged particles in space, i.e., an ionization chamber and

Geiger-Mueller tube to measure total radiation, and a triple coincidence cosmic ray proportional counter. The probe also carries a micrometeorite counter, a magnetometer, and instruments for measurement of temperatures and attitude. Power is furnished by solar cells mounted on paddles. There are two transmitters, 5 watts and 150 watts, designed to permit communication at distances up to 50 million miles.

Tiros I is a 270 lb. satellite which carries two television cameras to observe cloud formations and transmit the pictures to stations on the ground. It was launched in a nearby circular orbit with perigee of 435 miles and apogee of 468 miles with a period of 99.15 minutes. It is stabilized by spinning, thus maintaining a fixed direction in space. Pictures are obtained when the satellite is in that part of its orbit where the camera sees the sunlit portion of the earth. The satellite is provided with tape recorders which can record as many as 32 pictures for later transmission to the ground stations. One of the recorders is at present inoperative. Thousands of pictures have been obtained of cloud formations. Tiros promises a major forward step in observations of major storms and frontal systems. On the basis of this and future meteorological satellites, it is hoped to develop within a few years an operational system for routine use in weather forecasting.

For present purposes we are interested in the bearing of the information obtained on the prospects for space travel by man. Dr. Homer E. Newell, Jr. has recently[20] discussed this problem in some detail. The data obtained on the pressure, density, and temperature are required for rational design of any space craft, whether carrying man or instruments. Similarly data on the ionosphere are of interest because of the electrical charging of the vehicle and its effects on radio communication from the vehicle and on its drag.

One of the major results of our first satellite launchings was the discovery by James A. Van Allen and his colleagues of a belt of charged particles trapped in the magnetic field of the earth which produced radiation on striking a space vehicle. Further studies have shown that the structure of this region is quite complex and the outer zone varies in extent with solar activity. Newell's assessment of the situation is as follows:

"The radiation trapped in the Van Allen radiation belt may be a serious radiological hazard to the crews of future space craft or space stations. There is not yet available enough detail on the particles to provide a full answer to the question of how great this hazard is. The data presently at hand indicate that exposure levels would be in the range from 2 to 50 roentgens per person in the case of a rocket flying directly through the radiation belt to outer space. These radiation levels are well below the lethal dosage for human beings and may be further reduced by appropriate shielding. Moreover, it may be possible to launch a craft into outer space through the funnel-shaped region around the magnetic poles, thereby avoiding passage through the radiation belt. This cannot, however, be done in the case of orbiting satellite stations; if these are too high, they will continually enter and leave the radiation belt. In this case, the accumulated exposure might well become so great as to prohibit the use of the station. Thus, it may be necessary for manned satellites, at least the early ones, to be placed in orbits around the equatorial belt and to remain at relatively low altitudes---say, below 600 kilometers. It should be noted, however, that Winckler and his co-workers, in recent balloon flights, detected heavy fluxes of protons of 100-million-volt energy at low altitudes at the time of a major solar flare. It appears that the radiological hazard in space flight may be serious for limited periods during times of unusual solar activity."

In addition to the hazard of the radiation belt, there is still much to be learned about cosmic rays, particularly the roughly one percent consisting of heavy nuclei, and about the electromagnetic radiation from the sun. The designer may have to make some provision against possible effects on man of these features of the environment. The designer also needs more detailed information on meteoroids and micrometeorites in order to design an adequately protected structure.

From this brief review of our beginning steps in the exploration of space we see that we have learned much but that much basic information is yet to be obtained before man ventures very far away from the earth. Specifically, there are formidable technical developments needed to assure the success of manned journeys to the moon and to the planets of the solar system.

Need for a Broad Foundation of Research and Technological Development

The current state of the art of space technology permits certain types of space flight missions which have produced important new knowledge as just described. Knowledge is adequate, as will be discussed later, to begin to gain experience with man himself in the space environment. If, however, substantial progress is to be made, we must follow the method so successful in aeronautical development. In this field, we found that the conduct of a broad program of laboratory research and technological development in many areas of science and technology in ground facilities advanced the state of the art more rapidly than could be done by flight experience alone.

These areas are often described as problem areas. However, they must not be thought of as problems which must be solved before man can begin to venture into space. Rather they are the areas in which the current state of knowledge presently limits the performance which can be realized in flight missions.

Thus U.S. space missions are limited by the present state of the art of propulsion as embodied in available launch vehicles. Our payload weights are limited to a few hundred pounds. As a consequence we are unable to include certain accurate guidance systems now available from ballistic missile developments in the upper stages of our launch vehicles. The end result is a limitation on the types of flight missions which we can undertake with assurance of success.

Steps are of course underway to accelerate developments in the propulsion field to gain increased thrust capability at the earliest possible date. But the propulsion problem is not a single problem solved by the development of a single new propulsion system. We must maintain steady progress not only through study of larger chemical rocket systems but through basic research in fuels and combustion, and by research and development on new systems such as nuclear rockets and nuclear-electric propulsion systems. Without going into technical detail, missions with the very large payloads required for the travel of man to Mars or Venus cannot be undertaken before the foundations are laid to make possible propulsion systems of adequate performance.

There are many other areas related to systems associated with the overall performance and utility of the vehicle itself. Guidance and control is an obvious area in which continuous progress is required. At present guidance usually ceases at burnout of the first or second stage rocket, reliance being placed on spinning the upper stages to preserve direction. We see already the need for and are doing research on improved methods of attitude control, trajectory modification by mid-course guidance, and for terminal guidance as the moon or planet is approached. Another obvious area is that of energy sources and conversion systems to power the equipment in the space craft and to provide maneuvering power. We began with chemical batteries of limited life. We are now using solar power to keep batteries charged, a system adequate for smaller unmanned space craft and permitting operation for a year or more in the absence of equipment failure. We have under development nuclear-electric systems of greater power, identified in the press and technical literature as SNAP systems.

For the travel of man himself we encounter other problem areas. We are unable to make any large modification in man himself and we therefore must provide him with the environment to which he is accustomed, or as nearly so as possible, including eventually the psychological and social factors. We have had limited experience with some of these problems in the environment of submarines and aircraft. It is apparent that man must travel in a closed cabin at or near atmospheric pressure with an atmosphere of suitable composition and with temperature controlled within narrow limits. Certain measures such as g-suits, special couch supports or restraining belts must be used to counter the effects of large accelerations, which, even with such protection, must be restricted to tolerable limits. Noise and vibration must be within certain limits. In space travel in free space, the acceleration of gravity is absent. Its effects on humans and animals are under study. This condition can probably be tolerated for hours but long exposure may prove harmful. If so, the designer will have to provide an artificial gravity field by the use of centrifugal force. The present state of the art forms a sufficient foundation for space flights of short duration, i.e., for a few hours or perhaps days. But we do not have a solid foundation for manned flights lasting for months or years.

As soon as we begin to consider travel of man in space for these longer periods of time, a host of new problems arise, associated with supply and logistics. Food, oxygen, and water must be continuously available, and the weight required for long missions becomes very great indeed. Further the life processes of man produce waste products in the form of carbon dioxide, excreted water and solid matter which must be disposed of. In these wastes are a large number of chemical compounds in very small amounts which have deleterious effects if accumulated in an enclosed space over a long time.

Such considerations lead to the study of closed ecological systems, i.e., those which reproduce on a small scale the food growth processes and the water, oxygen, and other chemical cycles which take place in the natural earth environment. Thus experiments are needed on the growth of food by photosynthetic action of sunlight, on chemical or biological systems to free oxygen from the exhaled carbon dioxide, and on water purification systems. Knowledge in this area is still fragmentary. There are many unsolved problems in human physiology, particularly those connected with the utilization of minute quantities of many chemical elements. We may avoid these problems in our first short journeys but the practicability of longer journeys is dependent on continuous progress in this problem area.

The solution of man's environmental and supply problems involves additional energy utilization and additional mechanical and electrical systems. His life hangs on their continued operation over the months and years required for the desired missions. We are thus face-to-face with the difficult problem of developing long-life equipment of high reliability. The study of design methods and test procedures to assure high reliability and long life is receiving increased attention.

Finally there is the problem of adequate knowledge of the space environment itself with special reference to new hazards to man which may require protection. The most obvious problems are those related to radiation, cosmic rays, and meteorites which are under active study in the current space flight program.

A review of these many areas in which new knowledge is needed indicates the broad nature of the program required to eventually bring about the exploration of the solar system by man. The time scale of any specific mission is fixed by the rate at which we push forward.

Milestones of Space Exploration

The assessment of the future course of space exploration is a matter of extrapolation of past experience in the light of the foreseen problems. As such it is highly speculative. Prediction of the direction of technical progress is usually more reliable than predictions of time scale. A major uncertainty is the magnitude of the resources which any one nation or the world as a whole will devote to space exploration. The predictions of any one individual are likely to be colored by his mood of optimism or pessimism and the degree of his responsibility for making the prophecies come true. In the attempt to provide a better assessment than the judgment of one individual, we may consider the views recorded in two studies of the next ten years in space exploration.

One study consists of a staff report of the Select Committee on Astronautics and Space Exploration published on January 2, 1959 under the title, "The Next Ten Years in Space, 1959-1969." This report is based on a summary of the views of 56 scientists, engineers, industrialists, military officials, and Government administrators concerned with the national space program. The report contains the statements of the 56 individuals as well as a summary by the staff of the Committee.

As might be expected the predictions vary widely. Nevertheless there was substantial agreement on the progression of steps to be followed as man travels to greater and greater distances from the earth. These are the development of manned earth satellites, and of manned space stations, i.e., large satellites carrying several men, circumnavigation of the moon by man and return to earth, landing on the moon and return, manned expedition to Mars and Venus, the nearest planets. There were few attempts to forecast steps beyond Mars and Venus.

It is noteworthy that not one of the 56 questioned the possibility of man's reaching the moon. The only question appeared to be when. Although a few forecast the landing of man on the moon near the end of the decade, if a very high priority were placed on this goal, the majority placed the date a few years beyond the ten-year period. It was generally believed that the circumlunar flight of man would be accomplished before 1969.

The second group, whose collective views are worthy of consideration, consists of the scientists, engineers, and administrators of my own agency, the National Aeronautics and Space Administration, who are charged by the Congress of the United States with the responsibility for the exploration of space for peaceful purposes and the general welfare. In January of this year the NASA presented to Congress its Ten-Year Plan of space activities. About 28 major vehicle launchings per year are anticipated. Launch vehicles of increasing capability are under development and the weight of the largest individual space craft that can be launched into a low altitude earth orbit of about 300 miles increases from about two hundred pounds to more than fifty thousand pounds at the end of the decade. Correspondingly the weight capability for other more difficult missions to the moon and planets will increase by a large factor.

The NASA Ten-Year Plan includes a list of mission target dates. The manned missions included are the first suborbital flight of an astronaut during this calendar year, the orbital flight of an astronaut in 1961, first launching in a program leading to manned circumlunar flight and to permanent near-earth space station in 1965 to 1967, with manned flight to the moon beyond 1970.

The program includes many unmanned missions, which support the later manned missions, such as the first launching of an unmanned vehicle for controlled landing on the moon in 1963 to 1964 and unmanned lunar circumnavigation and return to earth in 1964. In addition, launchings of unmanned missions to the vicinity of Mars and Venus in 1962 and 1964 are included as well as the first launching of an orbiting astronomical and radio astronomy observatory in 1963 to 1964.

Speculative Course of Future Development

Only a few scientists have attempted to speculate about the distant future, although many others have exercised imagination without the restraints of current scientific knowledge. Extension of space travel to the limits of the solar system is certainly conceivable of accomplishment in several decades. Travel to the stars is quite another matter. The nearest star is 25 million million miles away. It takes light more than four years to make the journey.

Hence travel of man could be practical only if the velocity of the space craft approaches a large fraction of the velocity of light. In the Congressional study referred to previously, Prof. Dr. Ing. Eugen Sänger of the Technische Hochschule at Stuttgart states: "According to present-day knowledge the development will be via thermal atomic rockets, ionic rockets to field-quantum rockets, e.g., photon rockets, which will result in flying velocities so high that, maybe in the next century, fixed star systems, which are millions of light years away, can be reached within a few years of the lifetime of the crew." Extrapolation to the next century is probably not very reliable.

Milestones of space exploration of interest to many are the dates when flight in space, either suborbital to great distances on the earth, in earth satellite orbits, or to the moon and planets, will be as routine and familiar as the ocean-spanning travel in the jet transport airplanes of today. In my opinion these milestones will be reached but they are too far away to be accurately forecast. I will take refuge in paraphrasing the words of A. F. Zahm[21] in 1894 with reference to the conquest of the air: It were vain for us to speculate on the eventualities of the conquest of space, for they are incalculable.

Project Mercury

Let us then leave speculation about the future and return to the facts about the activities of today as we approach the first travel of man in orbital flight about the earth. The effort of the United States is known as Project Mercury. Its objective is to determine the capabilities of man to contribute to space exploration.

There are differences of opinion about the contribution which man can make to the exploration of space in the near future. Some feel that any desired task can be done by automatic equipment. Experience with research airplanes has emphasized the limitations of automatic devices; they can deal only with completely foreseen events based on programs prepared in advance from complete knowledge. Only the skill of a Bridgeman could retain control and land the D558-2 airplane when it unexpectedly encountered a region of instability at high supersonic speed.

The characteristics of man not yet reproducible by an automatic device are, in the words of George A. Peters,[22] "his ability to make unrehearsed observations and decisions, to function effectively in rather ambiguous perceptual situations, to draw upon and use an immense existing data-storage capability, and to adapt or change his mind as the circumstances dictate...........He will probably find useful roles in flight management, scientific observation, maintenance and repair, reliability override, redundancy, or adjustment functions; special tasks such as the assembly of space stations, or merely to save the weight, cost, and development time of certain complex or highly specialized equipment."

While in a sense the astronaut in Project Mercury may be considered as a biological mechanism whose functioning is to be measured, he is far more than a passive specimen. Provision is made for him to perform functions of a pilot, flight engineer, navigator, and radio operator. To assure his safety there is being established a network of ground stations throughout the world with access to high-speed computers by means of which the space craft can be controlled from the ground when necessary. Because of the high velocity and the exactness required in maneuvers, the space craft is equipped with automatic sensing and control devices of the type already found necessary in high speed military aircraft. But the astronaut can make certain changes and adjustments, can control the attitude of the capsule, and can take emergency actions if the automatic devices should fail.

The astronaut is provided with navigation devices, and should be able to know his position at every moment. He is expected to maintain communication with the ground, reporting his own condition, the functioning of the craft and its equipment, and the observational data he is collecting. Thus, while the successful performance of the Project Mercury mission does indeed have high overtones of national prestige, it is primarily the necessary step to determine man's capabilities under the new environmental conditions of orbital flight. If, for example, it should turn out that the effects of weightlessness for extended periods greatly inhibited the ability of man to do the relatively simple tasks described, space travel of man would have to await the development of large capsules in which gravity could be simulated by centrifugal force.

The simplest approach to space craft design was chosen for Project Mercury, although it should not be considered that the space craft is simple. The capsule, in which the astronaut travels, is roughly the size and shape of an Indian tepee, with an extension at the top in which parachutes are housed for landing. The capsule is placed in a nearly circular orbit at an altitude between 100 and 150 miles by an Atlas intercontinental ballistic missile booster. At a height of 125 miles the speed is about 17,400 miles per hour and the three circuits around the earth planned for the mission are completed in about 4-1/2 hours. The launching will be made from Cape Canaveral, Florida and the recovery will take place in the water area of the Atlantic Missile Range.

The astronaut lies on his back, on a contour-fitting seat, for maximum protection against the high forces developed by the acceleration at takeoff. The capsule is provided with an escape system, in case the mission has to be interrupted. It is designed to operate automatically, if the rocket fails; or the ground crew can touch it off; or the pilot himself can operate it. A special escape rocket then catapults the capsule free of the booster, to an altitude where the landing parachute can be deployed; and he is lowered, in the capsule, to the ground or sea, just as in a normal landing.

To return to earth from orbit at the end of a successful launching, the capsule is turned so that its broad base, containing the heat shield and the retro-rockets will face in the direction of flight. The retro-rockets are fired, slowing the capsule below orbital speed. The capsule then descends gradually, base down, into the atmosphere again. The heat shield dissipates the heat energy developed on re-entry, and the air resistance slows the capsule still more. A small parachute is used for further retardation and then the main parachute deployed for landing. The normal landing will be on the water. Aircraft are guided by radio beacons on the capsule to its location. Surface vessels make the recovery.

Such is the Mercury mission. An exhaustive test program is in progress on every component of the vehicle and every phase of the flight, including the escape system maneuvers. Instrumented flights, and flights with animals, will precede manned flights. As mentioned earlier, it is hoped to have the first suborbital training flight of an astronaut, using a Redstone booster, during this calendar year, and the first orbital flight of an astronaut during the calendar year 1961. These dates are dependent on satisfactory results in the remaining test program for qualification of the capsule and its equipment, and on satisfactory performance of the tracking and recovery crews in the unmanned flights.

Why Explore Space?

Our review of the prospects for space travel has led us from the fantasies of centuries ago to the events of the last three years, then to an assessment of the problems of manned space flight to the moon and planets and into the milestones of future development. We have considered the probable advances in the next decade with some assurance, and speculated in more general terms about the following years. In view of the expectations of the science fiction writers, and of other imaginative thinkers, the rate of advance may seem slow. Even so, the rate of expenditure will soon surpass one billion dollars per year. The plans and program are keyed to a sound but bold scientific and engineering approach as illustrated in the more detailed report on the research and development leading to the orbital flight of an astronaut.

The actual beginning of the construction of a vehicle for manned space travel has stirred the imagination of people everywhere and evoked emotional as well as rational responses. The attention of the public has been aroused to contemplate the tremendous dimensions of the universe, almost infinite by comparison with terrestrial distances. Twenty-six million miles to Venus, forty-nine million miles to Mars, 3680 million miles from the sun to Pluto at the outer edge of the solar system. The nearest of the stars is twenty-five million million miles away, and travel to it at 10 miles per second would require 80,000 years. Is the travel of man to the stars a futile dream? Each generation of man builds on the shoulders of the past. The exploration of space has begun; who now can set limits to its future accomplishments?

Many of our fellow citizens, busy with everyday living, have been incited to consider an age-old question: Are the earth and man unique creations or are there intelligent beings on other celestial bodies elsewhere in the universe? What is the chemistry of their life processes? To what depths of understanding of the universe have their minds penetrated? What is the nature of their culture, their religious and philosophical beliefs? As already mentioned prominent scientists in the early years of the nineteenth century discussed suitable means of communication with the residents of other planets, proposing the language of mathematics as the universal language. Today we read in the press that scientists of our day listen for intelligible messages among the radio signals from outer space.

Is this urge of man to explore and to know a sufficient reason to explore space? Certainly it is one of the reasons. New knowledge of the universe has in the past always been found to be a gold mine whose output had continuing repercussions on man's life on earth and on his intellectual and spiritual horizons. These later effects were at the time completely unforeseeable.

The exploration of space promises knowledge which can almost immediately be exploited for the economic and social benefit of mankind. The rich treasure returned promises to be a potent force in the affairs of men, as real as gold from the new world in the seventeenth century, or spices from India, or furs from the far North. The developments of meteorological and communications satellites are examples of peaceful uses which advance human welfare. Perhaps the greatest economic treasure is the advanced technology required for more and more difficult space missions. This new technology is advancing at a meteoric rate. Its benefits are spreading throughout our whole industrial and economic system.

It is generally believed that space exploration will make great contributions to national defense. As in the early days of the airplane we find it difficult to visualize the military applications of space craft beyond the near future. We foresee the use of space craft in disarmament inspection systems and in early warning systems. We are confident that other applications will develop. Some see space as a new arena of battle and conflict between nations and races. Certainly in the current cold warfare the rate and scale of our space activities are determined in large part by their probable political and psychological impact.

Some see space as a land of promise, where the nations, having failed to accommodate their differences on earth, may work together in the exploration and exploitation of space for peaceful purposes and for the benefit of mankind. Congress has in fact declared that such is the policy of the United States and created a special agency, the National Aeronautics and Space Administration, to implement that policy. We, in NASA, are convinced that every possible effort should be made to secure the cooperation of other nations. The task of space exploration is global in nature; it requires large resources; and its needs are better matched by the resources of the whole world than by those of one nation.

Conclusion

In summary, space will be explored for many reasons---scientific, economic, military, political. The question is not why, but when, and by whom? Its exploration with the powerful tools of satellites and space probes has already begun. Man himself is the most versatile observer of all and will take part in the exploration. We may be confident that in time space travel will be commonplace, although we are unable to forecast the details of future space craft or the timetable of their development. As Wilbur Wright indicated long ago: "But it is not really necessary to look too far into the future; we see enough already to be certain that it will be magnificent. Only let us hurry and open the roads."

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
1520 H Street, Northwest
Washington 25, D. C.

Friday, 22 April 1960

PRESS CONFERENCE
TIROS I

The Press Conference was called to order at 3:00 p.m. by Mr. Herb Rosen.

PARTICIPANTS:

DR. ABE SILVERSTEIN, Director of Space Flight Programs, National Aeronautics and Space Administration.

DR. MORRIS TEPPER, Chief of the Meteorological Satellite Program, National Aeronautics and Space Administration.

WILLIAM G. STROUD, Chief of Meteorology, Goddard Space Flight Center, National Aeronautics and Space Administration.

DR. F. W. REICHELDERFER, Chief of the U. S. Weather Bureau.

DR. HARRY WEXLER, Director of Meteorological Research, U. S. Weather Bureau.

DR. SIGMUND FRITZ, Chief Scientist of the Satellite Section, U. S. Weather Bureau.

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MR. ROSEN: May I have your attention please.

You were called here for a press conference, the purpose of which is to show examples of results to date of the TIROS I meteorological satellite experiment.

The satellite was launched in the early a.m. of April 1, 1960. Today marks the third week anniversary of this launching, and success.

People on our panel will discuss the vortices that have been observed, and the mosaics that have been developed from the data so far collected and transmitted by TIROS I. Everything is on the record.

The participants are: Dr. F. W. Reichelderfer, Chief of the U. S. Weather Bureau; Dr. Harry Wexler, Director of Meteorological Research; Dr. Sigmund Fritz, Chief Scientist of the Satellite Section; Dr. Abe Silverstein, Director of Space Flight Programs; Dr. Morris Tepper, Chief of the Meteorological Satellite Program; and William G. Stroud, Chief of Meteorology, Goddard Space Flight Center.

Dr. Silverstein will moderate. There are statements from the Department of Commerce.

If possible direct your queries to me so that I might repeat them. Then we will have a fairly reliable transcript of these proceedings for you, ready tomorrow morning.

I would like to turn the proceedings over to Dr. Abe Silverstein.

MR. SILVERSTEIN: Gentlemen, TIROS I, our experimental weather satellite, has now completed some 300 orbits around the Earth and has taken over 7,000 pictures of the clouds above the Earth.

As you know, TIROS I represents our first experiment in using the satellite technology to study the weather, and in a much larger sense to gain an understanding of the atmosphere surrounding the Earth.

We view our first results here as definitely research results in character. They help us understand what we can learn from the satellites that are used for these observations, and also have been able in some measure to gain some interesting understandings and observations and findings regarding the various formations that occur in large areas of cloud formations, and also some understanding of how to interpret them.

We have with us today people from the Weather Bureau who will make presentations on some of the results that have been obtained and give you some understanding of their meaning.

Next to me here is Dr. F. W. Reichelderfer, Chief of the Weather Bureau, who will read the Weather Bureau presentation.

MR. REICHELDERFER: Thank you, Dr. Silverstein.

Dr. Silverstein has referred to the fact that this is the beginning of a long-range program, and a research and experimental program. I would like to emphasize that, and to say, by way of a bit of amplification, that meteorologists have been called on for decades now to tell the public and to tell interested organizations, businesses, transportation, everybody interested in weather, in detail what is going on in the atmosphere, and to tell it in much greater detail than we have had observational data to support the service.

The satellite, the long-range program, offers a new viewpoint, a new capability for seeing what is going on in the atmosphere, not only in the cloud photographs that you are going to see more about today, but in other aspects of measuring the characteristics of the atmosphere of importance to humans, about which we have known relatively little and about which we have seen some in the newspapers with respect to other research programs that are going on.

I believe you have copies of this preliminary statement. I shall touch on only a few of the sentences which seem to be of special significance, and then quite rightfully I will ask Dr. Wexler to talk about the charts themselves.

He and Dr. Fritz have not only been closer to the almost hour by hour developments in the photographs than I have been, but Dr. Wexler in particular had the gleam in the eye about what satellites might do long before the rest of us did. He gave a talk before an audience at the Hayden Planetarium in 1954 in which he presented a picture of what cloud systems viewed from the satellite might look like over North and South America, and he even put in an idea of how a hurricane might appear. This turned out to be an excellent six-year in advance forecast.

So Dr. Wexler will cover most of the details about the photographs.

TIROS has revealed an unexpectedly large degree of organization in the cloud systems over much of the Earth's surface. The most striking patterns are the spiral cloud formations associated with large storms, some as much as 1500 miles in diameter, observed in such places as the United States, North Atlantic Ocean, North and South Pacific Oceans, and the Indian Ocean.

It is well known from radar observations that hurricanes are characterized by bands of clouds which spiral inward around the storm center. Now, as a direct result of TIROS we have seen that spiral banded cloud structure also exists around well-developed storms located outside of the Tropics.

A systematic inspection of these cloud pictures is just now getting underway. In the months ahead pictures are expected to reveal much new information about all sorts of atmospheric processes -- from fair weather situations to incipient storminess to the growth of a fully mature storm and its final dissipation.

Initial results from this one experimental satellite lead us to believe that a new era in meteorological observing is about to open to us. I might say there that I believe you all recognize that TIROS I is experimental, and we do not get complete observations from this satellite at the present time.

This will apply not only to uninhabited areas where meteorological observations are lacking in sufficient quantity, but even over densely populated areas where the satellite's view of cloud cover may introduce new concepts about atmospheric structure and will contribute materially to our understanding of the nature and life history of severe storms.

Meteorologists in general, I think I may say, are quite decidedly optimistic about what can be done, although the development road ahead is a long one and we may have many setbacks and many delays if we can judge from past experience in meteorological matters.

Thank you, gentlemen. I would like to ask Dr. Wexler to go ahead with some of the more specific descriptions.

MR. WEXLER: Gentlemen, for the first time meteorologists have an observing platform, a movable observing platform, commensurate with the global nature of the problem with which he deals. Oceanographers have a saying that seventy percent of the world is covered by water; meteorologists, that one hundred percent of the earth is covered by air. The meteorologists have had a difficult problem of trying to find out what is happening in the unknown areas of the atmosphere, which could conceivably affect populated areas.

With this first weather satellite we are beginning to see a solution on the horizon of an observing program which will go many, many years into the future, adding step by step to our knowledge of what takes place in this enormous blanket of air which is so enormous that if each person on earth were given an equal mass of the atmosphere to observe, he would have about 2.5 million tons of air to look at.

Among these first results that have come from TIROS in the three weeks it has been in orbit, we have gleaned some of the more striking examples and put them together in two rough categories of phenomena.

One, the large-scale vortex or cyclonic storm. I want to make sure that by "cyclonic storm" you don't interpret this to be tornadoes. "Cyclones" are used for "tornadoes". Cyclonic storms really mean a storm that is rotating counterclockwise in the Northern Hemisphere and is of very large size, hundreds to a few thousand miles in diameter. This is one category I shall emphasize in the beginning.

In the second category, the two last pictures here, which will be a mosaic on the one hand of about thirty different prints to show a stretch of clouds extending from the Pacific Coast eastward over to the Mediterranean and the Near East, and also a schematic representation of the same thing.

I would like to start with the first category. Here on this first placard here we have seven different examples of vortices observed by TIROS in both the Northern and Southern Hemispheres.

This picture, labeled 1, was the storm that was picked up in the early orbits of TIROS on the first day of launch, April 1st -- three weeks ago. This shows the storm 120 miles east of Cape Cod, centered at about this spot, with dry continental air streaming off the United States, not shown by clouds, and off the Coast the moist air streaming up to the north, counterclockwise around the center, producing widespread clouds and precipitation as far north as the Gulf of St. Lawrence.

On that same day mention was made of a storm in the Midwest. That is illustrated by photograph No. 2. This was centered over Southeast Nebraska, a rather extensive storm. Again, we have a clear air portion shown by a dark area, the ground underneath, which has less brightness than the clouds, the cold air from Canada streaming into that area, not characterized by clouds, and to the east the moist air from the Gulf of Mexico, in this general neighborhood, streaming around into that center and producing rather widespread rains. In this case near the Gulf of Mexico where the cloud is extremely bright, indicating that the clouds are very high, thunderstorms were found in that area.

It is a sort of situation in which tornadoes are to be found in this very bright cloudy area, especially this time of year in the Midwest.

A third vortex was observed also April 1st, in the Gulf of Alaska, five hundred miles southeast of Kodiak Island. You are some distance from these. I hope you can come and look at the details. The vortex circulation is clearly evidenced by the clouds which form in a circular array, and the large clear area in the center of the storm.

Number 4 picture refers to a very big storm 1500 miles in diameter located three hundred miles west of Ireland on April 2nd. This is a very old storm which was whirling around, had no fronts associated with it. It has long since wound up around the center. There is a rather well-marked structure to the clouds that you can see, I think, from where you are sitting, a banded structure. It is quite different from the pictures in the first two. These are storms mostly over the continental area or just off the coast. The storms over the oceans, so far as we have been able to see now, seem to show more of a banded structure. By that I mean circular bands of clouds, of width perhaps ranging from twenty miles to a few hundred miles, spiraling around the center in a counterclockwise manner.

Number 5 is the same storm, a day later, a different view of it, looking at it from the southwest instead of from the southeast. Here you can see the character of that circulation has changed. Instead of there being quite a few smaller bands there seems to be just one very large band winding around. The width of that band is quite considerable. We haven't really made any photogrametric measurements but I would estimate perhaps 150 miles wide at its widest point.

Number 6 is another vortex of a different character from the others. This was located 800 miles west of Southern California, April 4th, and has a vortex about a thousand miles in diameter. Here you can see superimposed several dimensions of bands. A very large banded structure, clear, cloud complex, clear again, another cloud complex. But then the individual band is broken up into a series of smaller bands, and probably if we had fine enough detail there would be smaller bands within those. The atmosphere seems to be capable of an immense variety of scale, and this shows in one picture a large variety of scale. We had a few ship reports in this area between Hawaii and California which led us to believe there was a storm there. We had no details. I will show you a weather map of that later on.

We certainly would not suspect from the few observations we did have this amount of structure to the storm. The interpretation of this amount of structure we are not in position to make. This is new to us, really. This will form a subject for study in the months and years to come.

Picture No. 7 is another vortex in the Southern Hemisphere, where they rotate clockwise instead counter-clockwise. This picture is more familiar to us because we have seen tropical cyclones as they call them in Australia -- we call them hurricanes and the Japanese call them typhoons. We have seen them by means of radar, limited portions. They are usually smaller vortices rather than the type shown here. This banded structure was known as a tropical storm but not suspected really in its high frequency for the storms outside the Tropics. This was the storm that was located about 1200 miles east of Brisbane, Australia, on Sunday, August 10th. You can see the cloudless eye of the storm.

So much for the first placard.

On the second placard I show you the weather maps associated with these things.

This is picture No. 2, the storm in the Midwest, as mentioned earlier, and the weather map associated with it. We have superimposed on this map the cloudy areas, and the area association is this: This cloud here is this right here; this clear area is this dark area. We have a sort of an optical image. Where it is dark, that is the ground. This is the reverse on the weather map.

Then there is this band of clouds coming down the cold fronts, this extremely bright series here, in which were imbedded some thunderstorms. The New England storm is shown here, again with its cloudless continental air coming in to the storm shown by this area here.

On this next placard over here we have a storm off west of Ireland, a very large storm, 1500 miles in diameter, on two successive days, April 2nd and 3rd. This just shows pictures that you have seen before, the difference in the details of the vortex on the first and second day and the weather maps that go along with it.

On this next placard we have the Gulf of Alaska storm, with a weather map associated with it. This weather map, of course, shows a rather great amount of lines, but I should hasten to say that they are based upon perhaps a dozen or fifteen reports over this vast area which is several times the area of the United States. A lot of this is based upon interpretation and continuity considerations, and it is notoriously well-known that when we try to do this over the oceans to the west of us that the opportunity for error is quite large indeed because of lack of observations.

No. 6 shows again this storm west of Southern California, this area here. It is a rather unusual place for a storm, where usually anti-cyclones are found, and the very complicated cloud picture above which I mentioned earlier.

Here we have the tropical storm picked up April 10th located at the time TIROS went by. I should hasten to add, this storm was well-known to the people in that area about a week before. We had word from New Caledonia there was a storm there. We thereupon programmed the satellite to observe it. As you know, we try to conserve power by programming it to take pictures only of interesting areas on the daylight side of the Earth. Having word of this, the program went on and pictures were taken at this point and continued for several minutes until the satellite got to this point. This is one of the several pictures taken in that area.

The Australia Meteorological Service sent us a weather map. It is interesting to show that in that storm area they had only three reports, one on the northern tip of New Zealand, one to the far west, one of the islands, and a ship not far from the center, and on that they base the whole structure, whereas from this we can see quite a lot of detail that you would not suspect from the surface observations.

So much for the vortices which are the most striking phenomena that we have seen so far, and we expect to learn a lot about these things and the message they are trying to portray as time goes on.

Now I would like to show a different type of picture, a mosaic on the one hand and a schematic cloud picture on the other.

This is a mosaic of some thirty pictures put together on orbits 14 and 15 as the satellite moved toward the southeast from this corner to this corner. The pictures start at that vortex off the Irish coast that I mentioned earlier, 400 miles west of Ireland, and they overlap. This orbit, number 14, took the picture of that vortex, and a hundred minutes later on orbit 15 we took a picture of the same storm. You can see details were carried through for the hundred minutes and probably even longer. So they overlap partially. This is a true geographical coverage.

As the pictures were taken we put these together in a mosaic showing the cloud pattern beginning at the vortex west of Ireland, showing the extensive cloud area over France and Great Britain, over the Swiss Alps, over Turkey, and a clear area in the Near East, Israel, Egypt, North Africa, and so on.

Finally, on this last chart, we have tried to show in a schematic manner how these things look. We have a weather representation of an area now much farther to the west. This is the west coast of the United States going all the way across the Atlantic, Europe, to the Near East. We pick up the mosaic from the preceding placard on this area. This is the vortex west of Ireland. These show the highs and lows in rough fashion of the fronts and arrows showing the stream lines.

What we tried to do here now is to piece together those clouds. This time we tried to represent them in true white against the dark background, showing the clouds as they look in these two orbits, orbit 28 and orbit 32 of the cloud representation, with the selected pictures of clouds of various portions. Here is the large vortex over Ireland and here the large scattered cloud masses mentioned earlier.

Gentlemen, this is all I have to say in regard to these few examples that have accumulated in the three weeks TIROS has been in operation.

MR. SILVERSTEIN: We can have questions now.

QUESTION: Dr. Wexler, are those clouds over Turkey associated with the storm off Ireland?

MR. WEXLER: No, they are not. The storm off Ireland has its eastermost extension off the British Isles. The clouds over Turkey are associated with no storm that I can see here. They are not associated with any storm nor any front. And it appears to be an example of orographically-induced clouds. That is air being forced to send them up in this area in Turkey and condensing it, giving clouds much the way they do over mountains. The clouds over the Alps are another example of that type.

QUESTION: Was there anything about this apiral vortex system that was new to you?

MR. WEXLER: Meteorologists, of course, have known that storms rotate in the sense they do as I described earlier. In the case of hurricanes, during the war when radar was first used to observe hurricanes, to everyone's astonishment instead of a solid cloud mass rotating around a center it was found that the cloud was broken up into bands, circular bands, spiraling in toward the center, bands perhaps being twenty to thirty miles wide with clear spaces of perhaps the same dimensions between. But no one really suspected that outside of the Tropics these storms would have such structure. Maybe some hardy souls made a prediction or surmised it but nobody really showed any definite proof. I would say this is the first definite proof we have that a large percentage of such storms as tropical storms do have such a banded structure. We are curious to see how high a percentage will finally emerge when we examine a lot more cases, and whether there is a true difference, say, between storms of the continental areas and storms over the oceans, whether there is more banded structure for oceanic storms than there is for continental storms.

QUESTION: When you get this satellite system working on a regular permanent basis where you call it something other than an experiment and get, for example, daily photographs that you can depend on, how much will this increase the accuracy and long range of your forecast, or do you expect that? If you don't, what do you expect?

MR. WEXLER: That is a very good question, of course. All I can say in reply to that is this: that meteorologists are a very audacious breed. Perhaps foolishly audacious in the sense that they have been trying to do the impossible. They have been trying to make details of the kind that Doctor Reichelderfer referred to earlier when they don't have observations to begin with, of that detail. Public pressure on us is so tremendous that we have done the best we could, and perhaps in some cases we have stuck our heads out in an endeavor to give good service. Despite the fact there has been a great enlargement of networks, horizontally, especially after the World War and during IGY, and vertically as balloons go higher, there still are enormous gaps.

I made a statement a few weeks ago that perhaps only one fifth of the atmospheric mass is anywhere reasonably adequately observed nowadays. If you are making a prediction for Washington, D. C., it is all right to have observations perhaps for one or two thousand miles around Washington, if you are interested in the next day or two. But if you are going into predictions for Washington, D. C., beyond that time, you have to know observations far out in the Pacific, over the Arctic, Siberia, and so on. And if you go beyond that, if you are trying to get some idea of what outlooks might be thirty days hence, one should have observations for even a larger area, perhaps the whole earth.

There is no question in the minds of meteorologists that beginning satellites in meteorology will fill in a large number of blank areas, which will give us cloud observations of this type which will enable us to know what is going on, so that we can improve and extend our weather maps on which our forecasts are based. Satellites will do more than just that. They will, when properly equipped with infrared equipment and radars and things like this, which will take years to come in, give us a basic understanding of the energy input and output of the atmosphere complex. To enable us to answer the question, not just how does the atmosphere look, but why it looks the way it does, will improve our understanding of these things, from which will come improved forecasting not only in the short range, but in the long range.

I wouldn't want to leave the impression that the availability of satellites, even in the full-fledged system which may come in several years hence, renders obsolete all of our other observing networks. Even the boldest optimist of the satellite meteorological fraternity will not say now, based on present knowledge, that we can get the same thing from a satellite that we can get from a radiosonde balloon which is sent up at 75 stations several times daily over the United States, and sends back pressure, temperature, humidity, and, by following the balloon we obtain the winds. The satellite will not compete with this for many years. This applies to other categories of observations. Satellite observations as they are coming in now will be supplementary to existing networks, and will enable us to get global coverage of the type that would be prohibitively expensive to try to do conventionally.

QUESTION: Dr. Wexler, have the results you have received so far from the experimental satellite increased your hopes for eventual success of a satellite system?

MR. WEXLER: Yes, without question. As Dr. Silverstein mentioned three weeks ago, we hadn't expected to get such fine pictures. To use two ends of the spectrum, the Vanguard Satellite released in February of last year, and the Atlas rocket shots of last August, the best opinion would be that the pictures that would come from TIROS would have been closer to the Vanguard type of photocell, a rough sort of brightness picture, than they would be to the fine detail of Atlas. The opinion now is that they are closer to the Atlas type than Vanguard. So this has been a very unexpected happy surprise to all of us. It makes us much more confident that the system to be developed in the future will yield even bigger returns, perhaps quicker than we thought possible before April 1.

MR. ROSEN: That is Vanguard II that he is referring to.

QUESTION: On the basis of what you are getting out of this satellite now, are you going to be able to make improved forecasts without waiting for the final operational system?

MR. WEXLER: This is rather difficult to answer. It is very difficult in the forecasts we make for the continental United States to give credit to any new detail or item that goes into the preparation of the forecast. There are so many ingredients that enter into it that it is very difficult to single out one and say that this causes this, and this causes a poor forecast.

In areas where we don't have very many observations, an observation of a storm is almost equal to that of a forecast. That is, you may not have the details of a storm, and you have a ship report here or there, and you know there is something out there, but you are not too sure what it is out there. Having such observations available will strengthen the analyses in these remote areas and thus should render on a sporadic basis a better description of what is going on, which means automatically a better prediction in these remote areas.

But we will consider such returns to be still of a very experimental nature and we intend to keep this whole operation on a research level until such time as the system is in full operation.

QUESTION: Doctor, can you tell us pretty much fairly close what percentage of accuracy you have in weather forecasting now, and what improvement you expect in that percentage?

MR. ROSEN: Is this improvement from a satellite?

QUESTION: Any improvement at all.

MR. REICHELDERFER: One of the values of my position is that I can be the goat for a question of that kind.

We are asked this question quite frequently and quite reasonably. It so happens that we are consulting today with a team of consultants that have been going into the question of forecast verification and forecast accuracy for aviation purposes. It is almost impossible to give you an intelligent single figure. Let me give you some definite figures.

For example, for Los Angeles the figures, as I recall, for forecasting visibility two hours ahead of time were of the order of 80 or 90 percent; six hours ahead of time, 70 or 80 percent; and ten or twelve hours ahead of time, it fell off to perhaps 60 or 70 percent. The verification for the forecast and visibility in some other part of the country, where there are rapid changes, Portland, Maine, for example, would be quite different. The overall answer that we give to a question about accuracy is that for most practical purposes, for most public uses, the forecast elements are accurate in 80 or 85 percent of the time on a whole, month in, month out, and year in, year out.

You asked the further question as to whether there was much improvement. There is vast improvement in forecasting some things. Our ability to forecast tornadoes, while far from perfect, is very much better than it was five or six years ago. So in some sectors, some elements, there has been great improvement. In others there hasn't been as much improvement.

May I add, while I am at the microphone, that with reference to a previous question it is obvious, if you look at one of these photographs and see all of the details of individual cloud masses, that there is an infinite amount of study in trying to see what successive photographs may mean with reference to the development, the dissipation or the movement of individual cloud masses. I suppose we could turn a houndred thousand people to studying the details of these several hundred pictures we received so far, as to what they might mean, and still not extract all of the information from them. There is a much further study to come. It is impossible for us to say at the present state just how far these studies will carry us in the study of the atmosphere, and therefore how accurately we can predict coming weather.

QUESTION: I gathered from your answer, Dr. Wexler, to the previous question and several other questions, that you believe that for the next five years weather satellites simply will confirm information that we already have from other sources. Is that what you were trying to say, stripped down?

MR. WEXLER: I don't know how you arrived at that from the remarks I made. I think I tried to illustrate earlier that we had no idea, for example, that there was this banded structure of these storms out in the Tropics. This is something new that has come in as a result of the satellites. Just what this means in the actual prediction of the movement of such storms, interpretation in terms of wind and weather, and the dissipation of storms, we don't know. Sure, we know storms rotated in a circular manner, but the fact that we have such indicators of motion as the banded cloud mass is something rather new.

As far as other aspects of conformation, I emphasize the global aspect of satellite capability. There is no wb5

other method I know of, except by the sheer expensive putting down of stations on land and sea, of knowing what the weather over the world looks like at any given time other than by satellites. What I mean by that is not in the fine detail that we get over the United States where we sent 75 or 80 radiosondes up several times a day, but just in broad outline as shown by clouds. That would fill up these enormous blank areas where storms can reside undetected for a week or so without our knowing about them.

QUESTION: Is the satellite working satisfactorily, or has any of it broken down, and if so, when?

MR. SILVERSTEIN: Mr. Stroud?

MR. STROUD: The operation of the satellite has not changed since the last time we reported on its operation to the group that was here. After the 22nd orbit the narrow angle camera remote picture-taking capability was destroyed for one reason or another. We do not know why. We still have troubles with the horizontal scanner which was intended to indicate the attitude of the satellite. Neither of these is catastrophic in any sense, and I think the data we have here illustrates that despite a few problems which we intend to correct, we are still getting good data.

QUESTION: If a satellite system, as envisioned by Dr. Wexler and others, costs "x" dollars, how much more will it cost to produce the same results with surface installations?

MR. ROSEN: I think the question is trying to compare the cost of detect of a surface system against the satellite system.

MR. REICHELDERFER: This question, of course, has occurred to people. I don't know of any estimate that is of any value at all. We do know that for a very few stationed vessels in the Atlantic, for example, the cost runs up, to the United States alone, of the order of 25 to 50 million dollars a year. So that the question is difficult because, as Dr. Wexler pointed out, the satellite is not a substitute for some other surface observations; for example, in hurricane reconnaissance aircraft. If we were to do the whole job by aircraft as we thought at one time we might have to do, it would take a lot of airplanes to cover the whole expanse of oceans.

Eventually, if the satellite can point out where the storms are, then relatively few aircraft can cover it, going out and seeing what it is made of. I think it is safe to say if you try to do the whole job by means other than satellites, the cost would be greater.

MR. ROSEN: There is also the fact that you can't look down.

MR. REICHELDERFER: This is true. You can't get the same picture.

QUESTION: Can you tell us what the angular deviation of the spin axis of the satellite is now, compared with the plane of the orbit? I understand it gradually loses sight of the Earth and then picks it up again.

MR. STROUD: This is a tough one for one reason: and that is that there is a very low precession rate in the satellite. This means that the spin axis is not staying fixed in space as we had intended it. This is of no consequence, again, as you can see from the data, except that we do not yet know this rate. It is something greater than one and a half hours, and it may be as much as several days. This is the precession rate, the rate at which the spin axis is wobbling. Until we know it we cannot predict at any one moment what the orientation of the spin axis is. The photogrametric process is looking at the pictures and, knowing the landmarks, will permit us to get an accurate determination in time. It will take some weeks of analysis to do this.

QUESTION: I understood that in about a month, for example, the spin axis of the satellite would be roughly 90 degrees to the plane of the orbit, so that it would see more of the horizon and more rarely would it look down and get a full shot of the Earth.

MR. STROUD: I think you are referring to the fact that after several months, of the order of three months, that this would probably occur, and we will not be able to take pictures of the Earth. We will not be looking at the Earth.

MR. ROSEN: This means that the whole satellite is twisted around so that the camera is never in view of the Earth.

QUESTION: None of this has taken place?

MR. STROUD: No.

wb7 QUESTION: What steps have you taken to make these photographs available to meteorologists of other nations?

MR. SILVERSTEIN: Thus far the photographs are being brought together for analysis at our Weather Bureau stations in this country. The experimental results will be studied, and an attempt made to find out the meaning of them, and at some later date we will release them to world weather stations.

Thus far nothing has been done.

QUESTION: Why have you not sent them out to other nations?

MR. SILVERSTEIN: Thus far we have been in the process of actually bringing these together and coordinating them, collating them, putting them into shape. We have really nothing yet to send out in a coordinated fashion.

It is raw data.

QUESTION: The point I am trying to get at, Dr. Silverstein, would it not help you tremendously in the analysis of these pictures if you could send them, say, to Australia so they could, in turn, correlate them with their own weather map? Why do you take on the whole burden yourself?

MR. SILVERSTEIN: This may very well be true in time. We are getting a lot of pictures here. We have a lot of pictures in a short time. We have a staff that is putting these together. We can't have some of these pictures floating around one place and some other. For example, in trying to put together the mosaics we need to have the data available to the experimenters. We look upon this thing as an experiment, not as an observational system as yet. You can't take the data and strew it around all over the world and expect to do an analysis of it. Later on perhaps, as we get the order into the material, we can take this point of view.

MR. ROSEN: I think I can also add: people even in Australia keep records of it, of their weather, and they can always check back if they want to check the research phenomena.

QUESTION: Dr. Wexler, why can't you keep one set of the prints and distribute duplicate sets of the prints and let these people make their own analysis while your people are working unhampered with the original set of prints?

MR. WEXLER: This is just what Dr. Silverstein said. There is no point in sending out a mass of pictures until you know where you are geographically, and the orientation of the camera axis, and have an idea of the geographical coordinates. As soon as the pictures have been put together and calibrated, so to speak, they will be distributed. I will say, speaking for the meteorological profession of this country, that we will need plenty of help in exploiting this material. I would hope that we might have the very expert assistance of our colleagues in other countries.

MR. SILVERSTEIN: If any of you have done experimental work, you know that when you get raw data it takes a certain period of time to organize this data. We have not processed it. This is raw experimental data.

QUESTION: What about the quality of films? Is it getting better or remaining the same?

MR. STROUD: We feel there has been improvement as we have learned how to handle the information and the films themselves. I think that the later orbits are very good.

QUESTION: How about the Hawaiian stations?

MR. ROSEN: What about the Hawaiian stations?

MR. STROUD: This is excellent, of equal quality.

QUESTION: There was some talk about turning the satellite to take a picture of the Moon. Have you done that yet?

MR. ROSEN: There was some talk -- I don't know where it originated -- of telling the satellite to take pictures of the Moon.

MR. STROUD: We have tried. The one set of data taken at Monmouth, where we had the best opportunity -- you remember it was just an opportunity, a chance, as we go by -- the pictures were very noisy. The Moon itself is only two television lines wide when viewed, and finding among the noise spots the little spot that might have been the Moon has not been successful.

MR. ROSEN: It is trying to compare taking pictures at 400 miles and 250,000 miles.

QUESTION: Have you found it necessary to spin up the revolutions of the satellite?

MR. STROUD: No. The decay, or the slowing down of the spin, has been so small that we have not yet attempted to fire the little rockets.

MR. ROSEN: Gentlemen, it looks like the dissertations and statements have answered all of your questions even before they were framed.

Thank you very much for your attention.

(Whereupon, at 3:50 p.m., the Press Conference was concluded.)

NEWS RELEASE

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
1520 H STREET, NORTHWEST WASHINGTON 25, D. C.
TELEPHONES: DUDLEY 2-6325 EXECUTIVE 3-3260

FOR RELEASE: Sunday AM's
April 24, 1960

RELEASE NO. 60-175
DU 2-6325

PIONEER V UNDERGOES "REPAIRS"

A space instrumentation expert this week made "analytical repairs" on Pioneer V from 5.5 million miles away without leaving his Los Angeles laboratory.

Trouble cropped up early this week in Pioneer V's "telebit" unit which collects information from experiment sensors before it is transmitted to Earth.

Values coming from the telebit channel which handles battery voltage levels, battery temperature readings and solar-cell paddle temperatures were obviously wrong. For instance, the probe would send a battery voltage level which was too low to operate the transmitter and yet the transmitter was operating.

Robert Gottfried, of Space Technology Laboratories, Inc., which assembled the Pioneer V payload, went to work on the problem. He was instrumental in the design of the "telebit" unit. After exhaustive analysis, he traced the trouble to a faulty diode -- a semi-conductor of electricity no bigger than the head of a pin.

Using an STL spare "telebit", Gottfried worked out a new translation code for the channel taking the bad diode into account. In a sense, he was able to fill in blanks caused by the malfunctioning component and interpret values which jibed with earlier Pioneer V readings.

The makeup of "telebit" emphasizes the complexity of Gottfried's task. The highly miniaturized 10-pound unit contains some 450 transistors, 1,500 diodes, 1,600 resistors, 1,000 capcitors and several thousand soldered connections.

In a telegram to STL, NASA Administrator T. Keith Glennan extended "hearty congratulations to the long-armed repair man who reached 5.5 million miles into space to clear a trouble that threatened the continuing performance of Pioneer V."

Meanwhile, the 94.8-pound probe in a Sun orbit between Earth and Venus continues to return good quality data from nearly six million miles away from Earth. At eight minutes past midnight, Monday morning, April 25, EST, the probe will pass the six-million mile mark.

Pioneer V payload conditions remain satisfactory. Paddle temperatures are running about 50 degrees F while battery temperatures are about 100 degrees F.

Quality of the data being received by the 250-foot tracking dish at Manchester, England, is good but at the 60-foot dish in South Point, Hawaii, the signal quality is poor. That's because the Hawaii station is nearing its reception limit on the probe's 5-watt transmitter.

In the next few weeks, a command will be sent the probe in an effort to turn on its 150-watt transmitter. Depending on component lifetime, this 150-watt unit should permit contact with the probe out to more than 50 million miles.

END

NEWS RELEASE

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
1520 H STREET, NORTHWEST · WASHINGTON 25, D. C.
TELEPHONES: DUDLEY 2-6325 · EXECUTIVE 3-3260

FOR RELEASE: April 26, 1960, 6 p.m.EDT
Tuesday

RELEASE NO. 60-176

NEGOTIATIONS ON SATURN SECOND STAGE BEGIN

The National Aeronautics and Space Administration announced today it will begin negotiations immediately with Douglas Aircraft Corp. on its proposal to build the second stage - designated S-4 - of the initial three-stage Saturn launch vehicle.

Estimated cost of development and production of nine second stages, including two spares, will be more than $65 million.

Powering the Saturn second stage will be a cluster of four Centaur-class engines developing a total of about 80,000 pounds thrust. These will be supplied under separate contract by the Pratt and Whitney Division of United Aircraft Corp. The third stage will be a modified Centaur stage driven by two of the same type engines which burn liquid oxygen and liquid hydrogen.

Mounted on the eight-engine Saturn first stage producing 1.5 million pounds of thrust, this three-stage combination will be able to boost a 25,000-pound payload into an Earth orbit or send a 12,000-pound instrumented spacecraft around the moon.

Douglas proposes to build the Saturn second stage at its Santa Monica, Calif., division, barge it to a test site near

Sacramento for static test firing, and then ship it East through the Panama Canal. The first of the S-4 stages would be freighted by barge to NASA's Marshall Space Flight Center at Huntsville, Ala., for checkout and mating with the eight-engine first stage, which is being constructed at the Marshall Center. Both stages would then be shipped by water to Cape Canaveral, Fla. Later S-4 stages will be shipped direct to Canaveral.

Shipment by water is dictated by the size of the stages. The second stage will stand 50 feet high and measure 18 feet in diameter, which rules out rail or truck transport.

Eleven companies submitted proposals for the second stage. Representatives of 35 companies attended the initial bidders conference at the Marshall Center in January.

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NEWS RELEASE

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
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Tuesday

LUNAR IMPACT PAYLOAD AWARD

Aeronutronic Division of Ford Motor Company today was selected by the National Aeronautics and Space Administration for negotiation leading to construction of a 300-pound instrumented package to be impacted on the moon within the next two years. It will ride pig-a-back on a larger spacecraft now being constructed at NASA's Jet Propulsion Laboratory in Pasadena, California.

At a distance about 20 to 25 miles from the surface of the moon, the mushroom-shaped instrument pack will be detached and a retro rocket will slow its speed to impact at less than 300 miles an hour. The parent craft will be destroyed as it impacts the moon at a speed of more than 5,000 miles an hour.

The 300-pound instrument package, containing a seismometer, temperature-recording devices and other instruments, will be protected by a honeycomb crushable structure designed to absorb severe impact. After the crash landing, the instruments will radio data back to Earth for a month or longer.

The main body of the spacecraft and the 300-pound capsule together weigh about 800 pounds. They will be boosted on the 60 to 70-hour flight to the moon by an Atlas-Agena B. The main body of the spacecraft will carry a television camera system for photographing the moon in addition to other scientific instrumentation.

Purpose of landing a small, rugged seismometer on the lunar surface is to learn something of the makeup of the moon. The seismic action caused by a moon-quake or a meteor impact would offer clues to the lunar structure.

NASA has seismometer development contracts for lunar missions with the California Institute of Technology and with Columbia University.

Aeronutronic was one of three companies asked to prepare advanced capsule design studies after a total of 13 companies had submitted proposals. The Newport Beach, California, Division of Ford estimates its part in the experiment will cost about $3.5 million. JPL will negotiate the contract and will provide technical direction.

- END -

Roswell

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

WASHINGTON 25, D. C.

SPACE AND ITS CHALLENGE TO ENGINEERING

by

Dr. John P. Hagen

Director, Office for the United Nations Conference

National Aeronautics and Space Administration

Speech To Be Delivered

before the

Newark College of Engineering

Newark, N. J.

on

April 28, 1960

SPACE AND ITS CHALLENGE TO ENGINEERING

by Dr. John P. Hagen
Director, Office for the United Nations Conference
National Aeronautics and Space Administration

It is a very real honor for me to speak to you on this occasion on the subject, "Space and Its Challenge to Engineering". There is a need for an understanding of this challenge. As with most problems of this sort, we are prone to turn to our educational system for the leadership necessary to cope with new and unforeseen situations. The consequence of this is that the educational institutions must have a better understanding of the true nature of the problem so that they can provide the means for leading us on our way out.

It is perhaps best to define our terms through a review of those aspects of the space program in which engineering plays a significant role. I might, in passing, make the point that the old-fashioned distinction between scientist and engineer is vanishing, that scientists and engineers nowadays work side by side more than they did in the past, and that in some areas the old roles have been interchanged - the activities of the engineer now lead the activities of the scientist. This is particularly true in the space program.

We are now engaged in engineering activity of a totally new kind. We must use powerful, yet finely designed vehicles, which must carry out complicated missions in a predetermined fashion with no opportunity for in-flight adjustment or repair. This equipment then must operate with absolute reliability, sometimes over long periods of time. In our plans for the near future, some of these equipments on arrival at their destination must perform complex tasks, report back their findings, and on command perform new tasks.

Some of the problem areas in which we are interested are wide in their application. We must be constantly engaged in the search for new, more powerful and more efficient means of propulsion. Presently we are using chemical propulsion, but for the future other more energetic means must be found. This search for new propulsion systems involves the very core of the materials problem, for it is in the rocket engine with gases flowing at extremely high temperatures and at high velocity that materials are subjected to the most severe treatment. Any step forward in the area of propulsion requires a solution, through development or choice of materials, for the problem of erosion at high temperatures.

Presently we are using liquified gases, such as liquid oxygen, for one of our propellants - one of our most promising future rockets involves the use of both liquid hydrogen and liquid oxygen. This means then that we must consider the strength of materials under heavy vibration at cryogenic temperatures. This is an exceedingly important problem inasmuch as, due to the nature of rocket flight, it it essential that the gauge of the materials used in the fuel tanks be a very minimum to conserve weight. Tanks, then, must be made strong enough to stand up under operation, but not a bit too strong. An associated problem is that of the piping of these liquids, one of which is at a temperature of 20° absolute, through the rocket, of the design and operation of regulators and valves for this purpose.

Carried in these vehicles are finely designed guidance mechanisms involving the multiple use of light but accurate gyros. These work in conjunction with servo-mechanisms for the eventual control of the rocket vehicle during its powered flight and later during its long coast toward its final mission. All in all, in the rocketry side of the space problem, there are many engineering problems and many problems which must be solved by a combination of a scientific and an engineering approach.

I should at this time interject the thought that the space effort is much more than rocketry. It is true that the popular impression of our space effort is that of launching rockets from Cape Canaveral, but this is only a very, very small part of the over-all effort, even though it presently has the greatest popular appeal and consumes the greater part of our assets.

Another of the important aspects of the space program where we have barely scratched the surface is in that of information processing. As you all know, it was just the other day that Pioneer V passed its five millionth mile on its trip toward the orbit of Venus. Using the large antennas available to us at Hawaii and in England, we are still able to communicate with this probe at this distance to gather information and to send commands. As the probe proceeds further on its course, the time will come when we will have to send a command to increase the transmitted power by a factor of 30 in order to insure successful communications to a distance of 50 million miles. Here we see one of the most important problems in the whole of the space effort. The amount of information that can be transmitted over a single carrier or in a single carrier band width is a function of the width of the band available. In the past the restrictions placed on the transmission of information have been not too severe and so never has optimum use of band width been attempted. Now, since every cycle of band width implies added weight in the rocket, and weight is at a premium, we must therefore insure that our telecommunications systems are designed to make the absolute maximum use of band width. This involves better hardware design, but it also involves further theoretical work on information theory. This problem can be aided by improvements in antennas. The greater the power gain of an antenna, the greater the signal-to-noise ratio and, therefore, the greater the information handling capability of the system will be. It involves also the continued improvements of radio receivers for every improvement in the sensitivity of the receiver is the equivalent to a proportional improvement in the antenna or in the amount of power which must be transmitted to achieve reliable communications. Small improvements in sensitivity can mean large savings of weight in transmitters and antennas.

Since weight is at a premium throughout this whole program, then, of course, the problem of miniaturization and microminiaturization of all possible components must be attacked with vigor and ingenuity.

We have made great strides in this country today and hopefully will make even greater strides in this direction. Our miniaturization efforts so far have been limited mostly to electronic components. We must think in terms of miniaturization of all other components.

The mathematics of the flight of a satellite in an orbit around the earth, or the flight of a space vehicle on its way from here to Mars, is complex. Astronomers, working in the field of celestial mechanics, starting from the laws of Newton have developed the mechanics of this flight so that if spherical symmetry is assumed then an exact solution exists for the orbit of one body about a second for all levels of relative energy. When a third body is introduced then the problem becomes so difficult that no general solution has ever been made. Similarly, if one of the bodies, and in particular the principal one, does not have spherical symmetry, but has for example an equatorial bulge such as that of the earth, then again the solution to the equations of motion is not exact. The space problem really demands that new, significant work be done in the area of celestial mechanics, so that the orbits of satellites around the earth, or the orbital track of a space vehicle travelling from the earth to a distant planet may be more closely predicted and, therefore, more carefully controlled.

Allied to the celestial mechanics problem and to that of information processing is another: the radio tracking of the motions of space vehicles. The systems of radio tracking that have been developed to date have done exceedingly well in keeping track of our present space satellite and space probes. But as the intensity of our effort increases, as more and more vehicles are sent off into space, it is going to become increasingly important that more accurate tracking be achieved in order to first, maintain a better record of the present positions of all of these objects and, secondly, to provide a better means for the eventual control of the flight of these vehicles. The use of the reduction of the tracking data and its application to the development of orbits and trajectories today involves the use of the largest computing machines available. This is occasioned by the fact that the problem is complex, that there is no exact solution, and so approximate and iterative methods must be used. The improvement and the miniaturization of computing machines with large storage capabilities is an essential to our further progress in space.

I have mentioned but a few of the problem areas facing us today. We are aware of the severe problems in each of these areas because they have in one way or another limited our present capability. The listing is not complete but it is clear from the recital of these few that there is adequate work for imaginative engineers for many years to come.

The Age of Space is an age of specialization, but it is important that in educating our youth we not attempt to specialize to exclusion.

It is important for the continued growth of the field that educational institutions apply themselves to the problems of the fundamentals, spending time with the individual student in specialization in a restricted number of fields. The day is no longer here when the colleges and universities can turn out the complete product. The function of the college and university is now to securely base the student on fundamentals, to allow the student to specialize only to the extent necessary to teach the processes of going from fundamental to specialty. The man can learn his specialty as he works after he leaves the educational institution. The reasons for this are many. First, the field of space exploration is too broad for any one man to master. Secondly, if education were to be based on specialization, then the moving technology would soon leave our educational institutions in the rear.

If one looks at the record of registrations of American students in engineering colleges in the last several years, he sees a very interesting picture. According to a recent publication, the total enrolled for first degrees in 1957 was some 258,000; in '58, 250,000; and in '59, 240,000. One might well ask, with the great interest presently expressed in technology, why the numbers of beginning engineering students are decreasing. Perhaps one of the reasons is that engineers in the past have tended toward specialization, whereas the scientific faculties have tended toward generalization. In this way, the young student rightly or wrongly looks upon engineering as a closed field, and science, such as chemistry or physics, to be more open-ended. The colleges and universities, in their engineering faculties, should build for the future. They must not build for tomorrow, but they must plan their curricula to prepare the student for the day after tomorrow.

We are in a deep struggle with our competitors. We can look about us today and realize that we are faced with the prospect of half a billion Russians and one billion Chinese populating Eastern Europe and Asia before the end of this century. Each of these nations has under way a compulsive effort to excel in this technological age. Presently, our newspapers notwithstanding, we are in the lead, but we dare not relax and enjoy the fruits of our wealth. Our only salvation and hope to live as a free nation and a leader of free people everywhere is to plow profits back into our effort. One potent way to do this is to give more time to education and to teach our students to be more perceptive, to recognize the technological revolution and to master it.

Social problems we will have. Man has always been afraid of his new inventions and has been perversely adamant about adapting himself to the new and technically more advanced environment he creates. This problem has been more severe in this last 50-year span with more advances coming in this one generation than came in all the centuries since the Dark Ages. This extends from the very small to the very large. In this generation, we have unlocked the atom and have found there things such as electrons, protons and neutrons that we can only partially describe with mathematics, but we do not understand these things in the sense that we understand the thing, "chair" or "table". We have begun to map our own galazy of stars and, where once we were impressed with its immensity, now we blithely think of it as one of many hurtling at tremendous speeds through space - space whose boundaries we have never seen and perhaps never hope to see.

This newly discovered knowledge of the existence of uncertainty about the very small and the very large, at the two obvious boundaries of our sphere of knowledge, was uncovered at the beginning of this century when scientists had given the impression to all that precision of measurement would reveal the ultimate truth as a mere refinement of our then present knowledge. With the uncertainty of our knowledge of the small and our knowledge of the large, falling on this one generation, it is small wonder that the children raised in this technological tempest were emotionally unstable and have created the political morass that exists in the world today. It is one of the functions of science and technology, through the use of a common language and the knowledge of a common desire, to bring the people in this world closer together. We will come to realize that we are working toward the same ends, and that perhaps with the breaking through of this new frontier in space we will all have much more difficult and much more distant problems with which to occupy ourselves. I think the situation that we see today is perhaps best described by Mark Twain in his short story, Adam's Diary. Adam's only notation at one Sunday's end was, "Pulled through". So, too, we may "pull through" when Monday comes.

If America is to live up to its promise, then surely we must recognize the challenge of the future and we must be not afraid to step forward and to meet this challenge. We live in an era of technology. Perhaps science and engineering will help us to continue to lead the world toward better living, in peace, and in freedom.

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Aswell Return

Dr. Wernher von Braun
American Newspaper Publishers Assn
Waldorf-Astoria
New York City
28 April 1960

Mr. Chairman, Distinguished Guests, Ladies and Gentlemen:

I consider it a distinct privilege to address this audience representing the great newspapers of America. To men like myself, who have lived in the environment of dictatorship where free speech and the free press were totally unknown, the newspaper seems perhaps the most unique of our cherished institutions.

I want to acknowledge the debt that the country's rocket program owes the press. Your persistent and critical interest has acquainted the public with the facts and the implications of our expanding scientific and military missile and space programs. You have been largely responsible for opening the public mind to the concept of human activities in this strange, new dimension which is as old as time. You have facilitated our progress because what we do largely depends upon the people's acceptance of the immediate and ultimate objectives of the national space program.

Wendell Phillips once remarked that "we live under a government of men and morning newspapers." I rather suspect the afternoon dailies would take issue with that statement, but I know that the attention the press has paid to our work has made it possible for us to continue it.

The eager reception accorded space experiments seems little short of miraculous in view of the fact that the Space Age began just a trifle more than two years ago. Matters which formerly were the exclusive domain of science fiction, or a few pioneering scientists, are the Page One stories of today's newspapers. They are usually well-informed stories. Sometimes they are so complete that those working in the program are at a loss to understand how the information got out! The ability of your reporters to master abstruse details of this budding technology represents a journalistic triumph.

I confess that at times we feel the press and the public are running faster than the rocket men. We must solve knotty problems in metallurgy, chemistry, electronics and the other fields of knowledge involved in advancing the state of the art. Sometimes our progress appears painfully slow, but I assure you we are trying hard to catch up with you!

The revolutionary advances that have brought closer man's entry into outer space are wholly in character with the onward sweep of scientific discovery and engineering exploitation. The results have re-shaped many familiar institutions and ushered in new processes that profoundly influence our lives. This is a period of dynamic evolution which is pushing outward the horizons of human knowledge with explosive force. Yet while we seem to be probing completely new areas, I believe that we actually are finding immutable truth. As the late Justice Holmes said, we are catching echoes of the infinite, glimpsing its process and moving ever closer to learning the universal law.

There is a great challenge to all our communications media inherent in this Technological Revolution. This is the need to interpret and evaluate, as well as to record, the happenings in the physical sciences and technology, many of them seemingly unrelated, for the edification of the people and the advancement of human understanding.

Consider the repercussions which followed the first earth satellite launchings. These were simply scientific packages designed to investigate certain physical phenomena and to report data back to earth receiving stations. But the implications were not lost upon the press. As a result scarcely any field of human activity escaped the impact. Education, industry, business, politics, international affairs, even religion have been directly affected by these events.

Recently the Under Secretary of State, Mr. Livingston T. Merchant, told the House of Representatives that "the exploration and use of outer space have introduced a new element into the complex of factors governing relations among nations. What we do in this new field and the manner in which we do it have both actual and symbolic significance. Outer space clearly represents a field from which man may derive substantial benefits, into which man may strive to extend his power and influence, and about which conflicts may arise. The achievements of a nation in outer space may be construed by other nations as dramatically symbolizing national capabilities and effectiveness."

Those words point up some of the implications of the space program. Yet there is nothing even remotely political in the principal objectives which tie together its elements. These are the ultimate purposes for which we are striving:

First - to study the Earth and the Sun in order to understand how the Sun controls our planet.

Second - to learn the nature of the solar system and the Universe.

Third - to search for the origin of life and its likely presence outside the Earth.

I select the word "likely" with deliberate purpose. There is good reason to assume, on purely scientific grounds and on evidence adduced by observation, that life of some kind exists elsewhere in the Universe. In my opinion that is an entirely logical assumption. I cannot believe that the Power which created life and order confined all sensible organisms to this comparatively tiny planet. Our Sun is one of 100 billion stars in our galaxy. Our galaxy is one of billions of galaxies populating the Universe. It would be the height of presumption to think that we are the only living things in that enormous immensity!

I would not have you think that we expect to answer that riddle by next Tuesday. There are many unknowns to be answered before we can schedule the exploration of the more distant reaches of outer space. Most of these problems, however, are straight-forward engineering. They can be solved in time provided we continue the program on no less than the present level of effort, and hopefully with such increases as can be justified by successive developments.

Maximum interest has been aroused by the manned space flight program of the National Aeronautics and Space Administration. It will be a significant milestone when the first American astronaut returns safely to Earth from a flight through the vacuum of space. But I suggest that it will be an even more memorable occasion when the first American meets another being in space. We can hope the greeting will be "Hello, Earthman" and not "Welcome, Tovarishch!"

I earnestly hope that our people realize we are not playing a game reminiscent of "Follow the Leader" of our childhood. I am convinced that the enlightened self-interest of the United States urgently requires that we carry forward a broad and aggressive program to establish a total competence in space. That program has been carefully shaped to serve the high purposes enunciated by the President and almost unanimously supported by the Congress. It is as genuinely American as the five-cent cigar but it also holds out the promise of unlimited cooperation to men of good will everywhere.

Some concern has recently been expressed about a possible imbalance in our scientific and research efforts due to the attention being paid to space exploration. I believe, with one exception, that it is not a serious problem. The checks-and-balances which operate in the normal processes of government and the national economy assure a roughly balanced effort. The exception is the limited resources we are committing to pure, basic research. We are not investing enough to replenish the well of painfully acquired information built up over many years. This failure may be due to the failure of science to communicate in understandable terms, and to the failure to understand the needs of science resulting from inadequate communications.

Looking back to the days of relative famine that hampered the program before the first earth satellite appeared in our skies, it is astonishing that so much useful work was accomplished with so little. However, scientists have a way of making do whenever they are so firmly persuaded of the importance of their activity that nothing can stop them. We have come a long way. The budget prepared for NASA programs next year is three times greater than in 1959. Even so, the total represents not much more than one percent of the Federal budget and about one-tenth the sum which American industry plans to invest in research and development. So I do not believe we are spending the nation into economic bankruptcy in the space effort.

Our primary concern is scientific and it would be highly injurious to be required to justify the effort in terms of economic benefits alone.

The cash return from the substantial investment demanded by the program must come in the wake of the achievement. This is true of any exploratory work. I think no inventor , no explorer could ever predict exactly what would follow his accomplishment. Even Christopher Columbus could not have imagined all the wonders that would develop in the new World that he discovered. Human curiosity, nothing more than the desire to know the unknown, has motivated exploration and investigation since man first walked the land. It is one of the compelling reasons why men want to visit the Moon, and why we are now building the transportation systems capable of taking him there.

All useful products, the nation's industry, and our national power derive from intangible ideas relentlessly pursued by man seeking only to satisfy their curiosity or to increase human understanding. Because a couple of scientists wanted to know the source of the Sun's eternal heat we have thermonuclear fission - one of the great discoveries of all time and one that may eventually eliminate human toil and poverty. Man learned to fly and out of that achievement came aviation. Out of aviation came military bombers and commercial airliners, a vast industry, additional technological advancement, and a closer bond between peoples.

The same mechanism will operate as we proceed to explore and exploit the space environment. We know that the process will widen man's sphere of action. It will increase his knowledge. It will open the last frontier. No one can foretell all the benefits that may accrue. We simply cannot imagine, with minds limited by tradition, knowledge and experience to earth bound concepts, what will be the total effects upon national growth, virility, and productivity.

Winston Churchill once said that the destiny of mankind is not decided by material computation. When great causes are on the move, as he added, we learn that we are spirits, not animals, and that something is going on in space and time and beyond space and time which spells duty. We who are involved in this challenging enterprise feel a high sense of duty to demonstrate the ability of free men to assume clearly recognized leadership in the exploration of space as in all other areas of scientific and technological progress.

To achieve that goal we must understand the critical importance of creating the proper educational and intellectual climate. Grave warnings have been voiced by such experts as professor James B. Conant, who found -

and I quote - "an almost vicious over-emphasis on athletics" in our schools and by Dr. George Kistiakowsky, scientific advisor to the President, who pointed out that the scientist is almost an outcast in our social order. Conditions such as they have reported are scarcely conducive to attracting young minds to the study of science and engineering. If we fail to inspire our young people to enter these fields, the security, progress, and fate of our nation are in serious danger.

I suggest that we must make scientific careers at least as attractive as those offered by our free enterprise system. The crux of the problem of scientific education is the huge gap between the low relative incentives offered to the scientist and the high incentives offered by a free economy.

Our educational system is based upon the premise that every boy and girl is entitled to a higher education - whether he wants it or whether he is prepared to profit by it. It has become fashionable to compare our system with that of the Soviet Union, despite the glaring differences in motivation and objectives which dictate irreconcilable variations. The approach to scientific education in Russia is not unlike the philosophy on which our professional military academies operate. The basic requirement these academies must satisfy is to train a given number of officers each year for military careers. The Soviets operate their schools on the same basis. That is, the state determines how many physicists, how many mechanical enginners, how many chemists it will require. The schools must meet these quotas, and entry into those schools commits the individual, voluntarily or involuntarily, to accept the discipline the state decides is best for him. There is no counterpart in Russia for the American business man. Consequently the ambitious youth has only one opportunity for success and that is to pass through an educational system that operates on a survival-of-the-fittest basis.

Now I am not suggesting that we should abolish businessman or turn over to an all-powerful state the determination of every individual's place in society. I do want to point out that we cannot attract young minds to careers in science and engineering unless we offer them suitable recognition, as well as adequate remuneration. Bertrand Russell had something to say along these lines which I think is pertinent:

"It is a mistake to object on democratic grounds to the separation of abler from less able pupils. In matters that the public considers important no one dreams of such an application of supposed democracy. Everybody is willing to admit that some athletes are better than others and that movie stars deserve more honor than ordinary mortals. That is because they have a kind of skill which is much admired even by those who do not possess it. But intellectual ability, far from being admired, is positively and actively despised and even among grown-ups the term egg-head is not expressive of respect."

When a good scientific paper earns a student as much glory as we shower upon the halfback who scored the winning touchdown, we shall have restored the balance that is largely missing from our schools.

While the press has done much to popularize science and to encourage science fairs and competitions among teen-age youth, I suggest that more can and should be done in the national interest. Perhaps one solution would be to turn your sports writers loose in the scientific community! They might find really dramatic copy possibilities inside the cloistered laboratories.

Certainly the Fourth Estate has discovered a rich lode of news material in recent space experiments, such as the photography of cloud cover made possible by Tiros, the first meteorological satellite launched this year by NASA. As this program moves ahead with more sophisticated instrumentation, weather forecasting will become much more an exact science by reason of the improved data. It will then become possible to predict weather with sharply increased accuracy and reliability. As a consequence of adequate warning, countless human lives and billions of dollars in property may be spared from destruction. It is not impossible that advance indications of a single storm could repay the entire cost of the space program for any given year.

A brief outline of the 10-year program which NASA is pursuing affords a glimpse into the future that should excite any American:

In 1960 - the first sub-orbital astronaut flight

In 1961 - manned orbital flight and lunar impact of a scientific payload

1962 - the first space probe measurements in the vicinity of Venus and/or Mars

1963 - the first launching of a two-stage Saturn rocket, the largest space transportation system now in active development.

1963-4 - a controlled landing on the Moon and an orbiting astronomical and radio astronomy observatory

1964 - unmanned lunar circum-navigation and return to Earth, unmanned reconnaissance of Mars or Venus.

1965 thru 1967 - initial phases of the program leading to manned circum-lunar flight and establishment of a permanent space station

Beyond 1970 - manned flight to the Moon.

Yesterday, at Huntsville, we static fired all eight rocket engines of the immensely powerful Saturn for the first time. That very brief test marked a milestone in the progress of this space vehicle. More than 1,200,000 pounds of thrust were developed - by no means the maximum performance we anticipate later but more rocket power than had ever before been developed in the Free World. The Saturn system will give the United States a space capability of great possibilities. For example, satellites of 25,000 pounds initially and up to 75,000 pounds as more powerful upper stages become available. With smaller payloads it will be possible to achieve escape velocity - exceeding 24,000 miles per hour - and to fly two men around the Moon and back or to land a very substantial payload softly on the Moon's surface. It will be adequate to carry a sizable automatic radio relay station to the surfaces of Mars or Venus and to transmit back to Earth scientific information on the environment of those planets. Now you will see a short film which will demonstrate the progress and the potentials of this space vehicle.

(FILM)

The organization which I direct at the NASA Marshall Space Flight Center has the mission of developing and launching the super-boosters, as they are called in the industry, to carry forward the long-range program of space exploration. Other elements within NASA will provide the cargo for our rocket-powered trucks - the manned capsules, the reentry bodies and the scientific instrumentation which will record and report data concerning the physical phenomena of space and the nearer planets.

Even larger vehicles are in prospect. Another NASA program supports the development of a single liquid propellant engine that will generate as much thrust, 1,500,000 pounds, as the entire Saturn cluster. When this giant engine becomes available five years hence, we can begin to assemble the gigantic rockets for the next decade of even more challenging projects - the permanent orbital laboratory, the satellite base station for nuclear-powered ships penetrating deep into the Universe.

One of my colleagues, Dr. Ernst Stuhlinger, is the foremost exponent of ion propulsion, the advanced power source for deep space travel. He has calculated that an explorer travelling in an ion-propelled ship could make a circuit of the Universe in 42 years, following Einstein's theory and moving at speeds equivalent to the velocity of light. There is one small catch in this - while our friend speeds through the outer galaxies, Earth by our time would have aged some billions of years and, in all probability, there would be no Earth to which to return!

We haven't quite decided what the effect of his travel would be upon the occupant of the space ship. Perhaps this is the Fountain of Youth that Ponce de Leon sought before the rocket men invaded Florida!

The derivatives flowing out of the mainstream of space technology are contributing to the progress of industry and to the availability of new products which enrich our social structure. The rapid progress of electronics, the developments in the computer field, notable advances in chemistry, in metallurgy, in automation, may be traced back to the impetus of rocket development for both military and scientific requirements.

Certainly the space program will make a lasting contribution to the cause of human progress if it becomes the means by which to attract youth to science. A basic understanding of scientific discipline will be essential to the informed citizen in the years ahead because technology will inevitably dominate civilization to an even greater extent.

Science is becoming a comprehensive whole. Chemistry is merging with the newer physics, and with biology, to become the key to the life sciences and a controlling factor in industrial power. Great discoveries lie ahead as nuclear physicists probe for the ultimate nature of matter. These are some of the windows through which trained minds can search for fundamental truth.

The country's overall need cannot be satisfied alone by more and better prepared engineers and scientists. They cannot exist and function in a vacuum. They must have the resources essential to their work. They must have an atmosphere in which they can operate with deep personal interest and the enthusiasm that makes the team more than the sum of the individual capabilities of its members. This calls for the sympathetic understanding and the continuing support of their fellow citizens.

To achieve that happy environment requires the constant attention of the American press. You can report the progress of the laboratory and the engineering center. You can emphasize their needs and their problems. You can interpret the implications of their accomplishments and explain these affairs to the people who are the source of all power and strength in this democracy. Through enlightened commentary, you can assure that the human and moral aspects are not overlooked in the search for the resources of power.

If we can achieve that happy relationship and the recognition of mutual dependency and obligations between the scientist and the public, there is no limit to the progress we may confidently anticipate. Putting aside selfish or parochial interest for the national welfare, we can preserve the image of America as the shining inspiration of free men. We can go forward unafraid into the Age of Space, sure that Almighty God will guide our way into his boundless Kingdom.

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
Washington, D.C.

PRESS CONFERENCE

PIONEER V

Friday, 29 April 1960

The press conference was called to order at 12:00 noon, Mr. Herb Rosen, Office of Public Information, NASA, presiding.

PANEL MEMBERS:

DR. HOMER NEWELL, Deputy Director, NASA Office of Space Flight Programs.

MR. HARRY GOETT, Director, NASA Goddard Space Flight Center.

DR. JOHN LINDSAY, NASA Project Scientist on Pioneer V, Goddard Space Flight Center.

MAJOR JAY SMITH, Director of Space Probe Projects, Air Force Ballistic Missile Division (ARDC), Inglewood, California.

DR. JOHN A. SIMPSON, Enrico Fermi Institute for Nuclear Studies, University of Chicago, Chicago, Illinois.

DR. JOHN WINCKLER, School of Physics, University of Minnesota, Minneapolis, Minnesota.

DR. CHARLES P. SONETT, Director of Space Physics Section, Research and Development Division, Space Technology Laboratories, Inc., Los Angeles, California.

DR. ADOLPH K. THIEL, Director, Experimental Space Projects, Space Technology Laboratories, Inc.

MR. PAUL GLASER, Assistant to the Director, Experimental Space Projects, Space Technology Laboratories, Inc.

MR. MAURICE DUBIN, Head of Aeronomy Section, NASA Office of Space Flight Programs, NASA Headquarters.

PANEL MEMBERS (continued):

DR. BRIAN O'BRIEN, Department of Physics and Astronomy, State University of Iowa, Iowa City, Iowa.

DR. ROBERT K. SOBERMAN, Cambridge Research Center, ARDC.

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MR. ROSEN: Welcome to another press conference at the National Aeronautics and Space Administration. We called you together for one major reason, and that is, as you well know, one of the principal missions of the National Aeronautics and Space Administration, to learn something about space, pursue space exploration projects, collect a world of data, analyze these data, and then report to the scientific and general communities on the results and the findings.

As you know, the American Geophysical Union is meeting in Washington. I think today is the first of a three-day session. A number of papers are being presented on the findings of Explorer VI, Explorer VII, and Pioneer V.

We have assembled here an illustrious group of experimenters who have designed equipment that is now flying either in Earth orbit or on its way into an Earth-Venus type of orbit.

In your press kits there are learned documents, abstracts of the papers that will be presented at the A.G.U. They will give you a five-minute or ten-minute summary of their findings and the conclusions that they have reached. After the conclusion of these presentations we will throw the discussion open to questions and answers from the panel.

They have behind them a battery of experts to fill in the blank spots of their own knowledge.

Let me introduce them to you and give you an idea of what they will be talking about.

On my far right, Dr. Brian O'Brien, Department of Physics and Astronomy, State University of Iowa, Iowa City, Iowa.

Dr. O'Brien will talk about the Explorer VII. He will be working hand in glove with the man immediately to his left, Dr. John Winckler, School of Physics, University of Minnesota, Minneapolis, Minnesota.

To his left is Mr. Harry Goett, the Director of the National Aeronautics and Space Administration,Goddard Space Flight Programs.

I want to point out that these experiments are conducted under the jurisdiction of the Goddard Space Flight Center.

Next to him is Dr. Homer Newell, Deputy Director, NASA, Office of Space Flight Programs.

Beside him is Dr. John A. Simpson, Enrico Fermi Institute for Nuclear Studies, University of Chicago, Chicago, Illinois.

He will talk about the Chicago experiment that was contained in Pioneer V.

Next is Dr. Charles P. Sonett, Director of Space Physics Section, Research and Development Division, Space Technology Laboratories, Inc., Los Angeles, California.

Dr. Sonett will talk about the magnetometer experiments.

Next to him is Dr. Adolph K. Thiel, Director, Experimental Space Projects, Space Technology Laboratories, Inc.

Dr. Thiel will give you some run-down on the position and performance of Pioneer V.

Next to him we have Mr. Maurice Dubin, Head of Aeronomy Section, NASA Office of Space Flight Programs, NASA Headquarters.

Mr. Dubin will talk about the meteorite experiment.

In the question and answer period, for those of you who want to use names, behind will be gentlemen who will be responding to questions that come from the floor. Reading from my right: Mr. Paul Glaser, Assistant to the Director, Experimental Space Projects, Space Technology Laboratories, Inc., John Lindsay, NASA Project Scientist on Pioneer V, Goddard Space Flight Center.

Next to him, Major Jay Smith, Director of Space Probe Projects, Air Force Ballistic Missile Division, ARDC, Inglewood, California.

Next to him, Dr. Robert K. Soberman, Cambridge Research Center, ARDC.

There is another correction to the press kit. On release 60-183, the Pioneer V statistics, there is on the very first line after "launch", altitude 78.1 degrees. Please delete that if you will.

From this point on I would like to turn the proceedings over to Dr. Homer Newell, who will carry on.

DR. NEWELL: Thank you, Herb.

The launching of a satellite or a space craft is of course an exciting event, especially when one gets back to news that the launching has been successful. But even more exciting is the influx of data from such a successful satellite or space craft. We are assembled here today to talk about data which has come back from Pioneer V primarily. However, -- and this is an interesting point that I think we should develop -- the data which is coming back from Pioneer V is adding to a picture that has been growing from the data coming back from previous probes and satellites.

You will find, as the experimenters review their results, that they will have reference to previous probes -- for example, Pioneer I -- and to previous satellites -- for example, Explorer VI.

In particular there is a satellite in operation right now which is still functioning, namely Explorer VII, which has given data that can be correlated with the information coming back from Pioneer V. For this reason we have Dr. O'Brien here to talk on Explorer VII.

The Pioneer V was instrumented, as you know, to study particles in space, and to observe magnetic fields encountered in space: the magnetic field of the Earth, and beyond the Earth in interplanetary space.

I should like to call your attention to an item that Mr. Rosen mentioned in his introduction, namely that at the American Geophysical Union meetings this afternoon, at the Department of Interior Auditorium at 2:00 o'clock, technical papers on the subject of this panel discussion will be given by the experimenters.

Without any further introduction on my part, then, let us turn to the main part of this session. I would like to call first on Dr. Adolph Thiel, of STL.

DR. THIEL: Ladies and gentlemen, Pioneer V is a scientific space probe, and the main purpose of this today is really to present to you the results as far as they have been developed from the scientific experiments.

Nevertheless, in starting off this session it might be useful to review very briefly the engineering performance of Pioneer V. I would like to in a very brief time give you some idea how Pioneer V, from an engineering viewpoint, has performed so far.

The first chart I have here summarizes the position of Pioneer V as a function of calendar days. At the present time, today, the Pioneer V is about 6.7 million miles from the Earth. The distance from Pioneer V to the Sun is about 90 million miles. The distance which Pioneer V actually has traveled in orbit is shown in this column. Today it has traveled something of the order of 383 or 384 million miles.

In the last column this might really best illustrate to you what these distances really mean. The last column summarizes the communication time between the ground station to the Pioneer V and back again. So you can see we are really reaching quite far into space. Today it takes, to communicate with Pioneer V, one minute and ten seconds. At the time of its closest approach to Venus, which is about August 10, this communication time will increase to about eight and a quarter minutes.

Also of interest might be how much tracking actually has been accomplished so far. As you know, Pioneer V is a control -- operates on a control command basis. In other words, we are commanding on and off from the ground the interrogation of Pioneer V.

So far this chart shows you what has been accumulated up to today, from the launch of March 11. At the beginning we had four ground stations. The first one, at Patrick, which handled only the launch phase itself, and Manchester, Singapore and Hawaii. Manchester operated for about two days, and then it dropped out simply because it could not communicate with the distance any more.

Today we still have in operation and will have in operation for quite a considerable time two stations, one in Manchester and the other in Hawaii. All together we have accumulated as of today 94 hours of tracking time. Ninety-four hours where we actually obtained data from Pioneer V.

We have operated the command system 227 times.

It might be of some interest to you gentlemen how we actually do this command on and off of Pioneer V interrogation. This does involve a rather complex schedule in exercise. A good example is shown on this chart. The chart shows you the visibility period from the various ground stations. In other words, it shows on a certain day -- and the day here is May 2 -- on the second of May the Pioneer V is visible from Singapore over this period of time; from Hawaii over this period of time; and from Manchester over this period of time.

Then we actually schedule certain tracking periods. The main thing which we have to consider here is to schedule these tracking periods such that we don't put an unreasonable burden on our batteries. Every time we are actually tracking we are draining the batteries. When we shut off the transmitter then the solar cells are recharging the batteries.

We have to be very careful that we do not overcharge the batteries, in other words, that we do not have too long a distance between the tracking periods.

As might come out a little later, we are preparing these charts in advance. On the other hand we also have to be very flexible and have to have the capability to change these tracking periods on very short notice. This happens whenever the experimenter is particularly interested to get a certain time. For instance, when a solar flare happens they call us up and ask us can you possibly change the tracking period and turn it on at this and this day.

So this is a normal scheduling chart which always might be modified by certain events.

This chart really shows you the performance of the engineering sub system in Pioneer V.

We have on our telemetry channel, in addition to getting all the scientific data back, we have one channel with which we supervise very carefully the performance of Pioneer V. We are measuring a number of parameters, as, for instance, the temperature in the converter, the temperature in the transmitter and specifically the temperature in the batteries, the paddle temperature, the lower shelf temperature, the battery voltage, and the receiver loop stress.

This chart can show you how well Pioneer V works from an engineering viewpoint.

This column gives the value which we predicted prior to launch.

This column shows you what we actually obtained.

As you can see, our temperature control system works rather well. We are somewhat off, but this is well within the tolerance which we had predicted.

Our battery voltage, which really is an indication of how well our solar power supply operates, is off by less than five per cent.

The next two charts give an indication of how long we actually can hopefully track Pioneer V. This chart shows the signal strength in the communication loop from the ground to Pioneer V for the station in Hawaii, which is this line, as well as from the station in Manchester.

In Hawaii the command threshold is this line here. In Hawaii the prediction was that we will lose the command capability on the white band when we reach out about six million miles. Actually it did happen that we had to go to another band just shortly before we reached this point here. It furthermore shows you that as far as Manchester is concerned we are predicting right now that we have the command capability well out to eighty to a hundred million miles.

As far as Hawaii is concerned, the command capability with the five watt transmitter probably will end somewhere around twenty or twenty-five million miles.

If you remember the first chart, the closest approach to Venus occurs at about forty-five million miles, well within the command capability of our command station at Manchester.

This chart shows you the communication loop capability from the Pioneer V down to the ground, which means it tells us how long we can receive it intelligently, the telemeter data, specifically scientific data.

Again, to make it very brief, it indicates here -- this again is the threshold -- that from Hawaii we will, with the five-watt transmitter, reach the point of not being able to obtain telemeter data from around six million miles.

Again this has been confirmed, despite the fact we still can communicate from Hawaii, the telemeter data right now with the five-watt transmitter is getting very weak. As a matter of fact, it is most of the time not useable.

When we go to the 150-watt transmitter, Hawaii will have the capability to operate at about twenty million miles.

Manchester will have the capability to operate at well up to one hundred million miles.

This then also raises the question: As you probably know we are still operating with the five-watt transmitter. As you can see from these two charts, we are approaching very rapidly the point where we are going to switch over from the five-watt transmitter to the 150-watt transmitter. In all probability this will happen within the next three weeks.

MR. GOETT: Thank you, Dr. Thiel.

Next I think we would like to hear from Dr. Simpson about the Chicago experiment.

DR. SIMPSON: I would like first to thank both the NASA organization and the Space Technology Laboratories, Dr. Thiel's group and the others, for the opportunity that has been given to some of us in the Universities to place on board vehicles like Pioneer V experiments that continue earlier work that we have been able to do in more limited ways either on the surface of the Earth or in balloons. So we look upon this as a real privilege and opportunity and we are delighted to talk about all the physics that we have been able to learn in making these experiments with you.

Since the launching of Pioneer V the solar conditions after launch remained relatively quiet until toward the 27th or 28th of March, whereupon, on the solar disk, with the sun rotating in this direction, as seen from the Earth, there appeared a region designated by the high-altitude observatory as H-15, in which there was a large number of at first relatively small solar flares occurring, and then within a relatively short period of time a large number of solar flares. So that, by the 28th or so of March, there was almost a continuous flaring in this region and in some similar regions not far away.

At the same time there was intense solar radio noise extending out into the corona considerable distances.

So I can report, in addition to the successful launching of Pioneer V, one had the almost ideal situation where first one had a quiet period to look at his instruments, to be sure that the calibrations were what you expected, to view the experiment we expected for the interplanetary cosmic rays, and so forth, and then discretely with this quiet background one got a tremendous series of events that form probably the main center of our discussion here today.

I mention these introductory remarks because I think they are pertinent to many of our discussions.

Very briefly, one of the outstanding flares produced a burst which appears to be a burst of plasma that started out on the 30th of March toward the Earth, and reached Pioneer V and the Earth on 0800, approximately, Universal Time, on the 31st of March. It produced a typical geomagnetic storm, the shaking of the Earth's field, distortion of the Earth's field, and at this time already one of the first results was obtained, namely, using our detector system identical with Explorer VI, which we discussed last fall at a similar press conference, we observed a sharp decrease of intensity in the Pioneer vehicle, a depression of the cosmic ray particles coming from the galaxy.

In the first slide you can see blocks of data as a function of time, including the period of March 31st. So that this depression of intensity from Explorer VI data, and the recent Pioneer results, when compared with the observations at the Earth simultaneously, using a neutron intensity monitor, proved to us that the sharp decrease of galactic cosmic ray intensity does not depend upon the existence of the Earth's electromagnetic system, and consequently tells us directly that we are here dealing with a plasma ejection from the sun. It provides us with some of the strongest experimental evidence we have to date for the existence of this type of mechanism. We do not know the details, but we know that there is a vast and extensive distorted magnetic field system in the vicinity of the Earth and Pioneer V at this time.

So the typical decrease, known as the Forbush decrease -- Dr. Scott Forbush, who is sitting here in the audience, who observed such variations even before World War II -- can now be identified as a phenomenon of solar origin and does not depend upon the Earth.

This is the first conclusion that we derive from Pioneer V results.

(Slide.)

Here is the date of launch. Each interval represents one day. We have indicated in a sort of histogram fashion the counting rate for one of the detectors in our system. Here you see this sharp decrease of intensity, representing the loss of approximately 28 percent of all the cosmic rays from the galaxy at this period of time.

Here is the flare which produced this effect. Here is the magnetic storm accompanying it on a time scale. This occurred at five million kilometers from the Earth and hence is completely independent of the Earth's system.

Now let us proceed to the next event.

The following day, on April 1st, there occurred another solar flare, outstanding in character, that resulted within the order of twenty minutes or so, resulted in the arrival of solar protons. These are the low-energy solar protons that have been seen during the IGY years up through to the present. They were detected in Pioneer V as a sharp increase in flux, but also observed at the Pole by Harold Leinbach, of the Geophysical Institute of Alabama, using radio absorption techniques, who was able to show that the increased ionization over the poles occurred at the time of the arrival of solar protons. And because of the prompt absorption that occurred there, essentially in coincidence with the observation of particles in Pioneer V, we see that there is no immediate hold-up of protons in the geomagnetic field; that these protons then come directly to the particular regions from space.

This is the other conclusion that we can draw.

On April 1st we can draw a further conclusion from this solar flare that occurred. This, incidentally, was the most outstanding solar flare that resulted in particles that we have observed in this period, but there were others, and I am not going to refer to them at this time, however.

The other interesting effect is the following: that at this time we have evidence that electrons also arrived. This is our first evidence that electrons from the sun find their way to the Earth relatively promptly and of intermediate energy. We don't know yet the energies because we have to calibrate our detectors in the laboratory for the energy range that we suspect, which came into play here, but we do know that the fluxes were the order of hundreds of times the cosmic ray flux.

So we see that from this electron emission we know that the sun accelerates electrons because we see the direct effect of the accelerated electrons.

In the next slide we show another conclusion derived from these measurements. You will notice in the previous slide that the high-energy particles essentially varied about horizontal line.

(Slide.)

When we look at a detector which looks for electrons we discover that there are burst periods in here where apparently Bremsstrahlung was appearing in our detector. We interpret this as the impingement of electrons upon the body of Pioneer V and upon the lead from our detector. You see, for example, on April 1st, here is the electron increase. Here is another solar flare April 5th, producing even more electron fluxes. Generally there is underlying an overall increase of intensity of electrons out at distances the order of one to five million kilometers.

We know that this is not an instrumental problem because by the 14th of August we have returned to the initial conditions that we had at the time of launching, and the radiation, at least for a short period of time, disappeared.

So we can therefore conclude that probably the radial sources which were present during this period also contain these energetic electrons, and at least some of them were able to escape and find their way to the Earth.

These are the immediate conclusions that one can derive from the initial reduction of data. They give us a considerable amount of insight into the origin of the plasma cloud coming from the sun. The plasma cloud probably carried some of this radition indicated in here. As you will hear from other speakers, there were accompanying effects in all detectors, including the magnetometer devices.

So the evidence at present then is that our theoretical picture, idealized model, of the way in which the geomagnetic storm gets under way, is beginning to be built up. And because we can prove the existence of the sharp Forbush decrease in space, we know experimentally that it must include the transportation of plasma.

I think that is all I should say right now.

Thank you.

MR. GOETT: Thank you, Dr. Simpson.

Now we would like to hear from Dr. Winckler , of the University of Minnesota, about the experiment for which he was responsible.

DR. WINCKLER: The detectors that we installed in Pioneer V were exactly the same as those carried in the Explorer VI. We are thus able to compare the results in deep space with the results obtained in the radiation belts around the Earth.

(Slide.)

These detectors go down to lower energies than those described by Dr. Simpson. In that sense, they complement each other very nicely.

The upper part of this slide shows the radiation fluxes measured in deep space, about five million kilometers from the Earth, at this point at least, in Pioneer V. That is the part above the dividing line here.

On this slide you will see four different types of radiation displayed by the two instruments. In general, the top line is the ionization rate, and the bottom line the counting rate. First of all, you see the Pioneer coming out of the Earth's radiation belts and at this point it is measuring the outer Van Allen regions, and the radiation intensity drops rapidly, and as the Pioneer V escapes the environment of the Earth, the radiation drops down to that level characteristic of free space, which is due to the galactic cosmic radiation.

This level continues for the first two weeks, as Dr. Simpson has told you, fairly regularly.

When this very active region appeared on the sun, however, many effects were observed. We have put here the little lines representing important solar eruptions. We have found that at least six of these solar eruptions produced these low-energy cosmic rays that we have observed with balloons and with Earth satellites in the past, and this is the third type of radiation. First the radiation belts, secondly the galactic radiation from cosmic rays, and thirdly the solar-produced particles or low-energy cosmic rays.

We have found that most flares on the sun greater than what is called Class 2 by the astronomers will produce these cosmic rays in various intensities. Here is a little blip which shows a very weak one, and here are two very substantial events which occurred on April 1st and 5th in time-associated solar flares.

We have studied the characteristics of these cosmic rays and obtained rather good values for the energy, the distribution of energies, the intensities, and so on.

The fourth type of radiation is of much softer quality and can be identified as X-rays, pretty much of the type that you find in a medical X-ray machine, which are produced -- and you see them in these intermediate times here -- by electrons bombarding the outside of the payload, producing X-rays which go in and then give a response on the instruments.

These are the four types of effects that we see and can identify.

We have at the same time conducted experiments with balloons flying over the north-central United States at the top of the atmosphere, and we find in one case at least very good correlation with these solar cosmic rays at balloon levels.

These cosmic rays in this case were of moderate intensity. Previously we have measured with balloons, when there were no satellites or space probes available, very intense bursts of these solar cosmic rays which on this scale would be off the top of the chart somewhere in intensity.

I would like to call your attention to a fact that you can't see, namely, that this is a contracted scale. This is one unit, ten units, a hundred units, and so on. It is what we call a logarithmic or compressed way of presenting the information.

By inference now, by comparing the direct balloon observations made at the same time as the space probe, we can conclude what would have been the most intense level of radiation from these solar particles in outer space. We find that it is very intense, and is in the region where definite biological effects will be produced.

We reached this conclusion previously from the balloon measurements. It is certainly confirmed now that we have an exact correlation between what we see on Earth and what we see in free space.

So even though one gets outside of the radiation belts of the Earth, one finds sporadically, as a result of solar activity, intense radiation which is very penetrating in character and which has to be seriously considered for its biological effects.

It is a very facinating scientific problem to unravel the source of these cosmic rays, how they are propagated through space. On this the Pioneer is giving a great deal of information.

The Earth satellite Explorer VII also observed both of these large bursts of radiation as it passed over Hudson's Bay region in its orbit around the Earth, and we have very satisfactory correlation between the counting instruments in the Pioneer V and the Earth satellite Explorer VII, and also the balloons at high altitude.

There was a very severe geomagnetic disturbance taking place at about this time on March 31st, and these wiggles are a magnetometer reading on the Earth's surface. This was a very severe storm which knocked out radio communications, induced voltages in submarine cables, and now we have a chance at last to see this storm in transit from the sun, and to study its properties.

Just after this storm -- and Dr. O'Brien will fill in the details for you on this -- the Explorer VII Earth satellite, which passes through the outer edge of the Earth's radiation belt, saw a very large increase in the intensity of the Van Allen electrons in the outer belt. This occurred in the week following this severe geomagnetic disturbance, which began right here. This was a very large increase. We have examined the records to see what radiation was observed coming from the sun which might account for this. We see only a relatively weak intensity of electrons of the type found in the outer radiation belts.

The difference in intensity between the electrons observed in Pioneer V in space coming from the sun and the electrons observed in the outer Van Allen regions of the Earth is something like a factor of 10,000. There is one electron here to 10,000 electrons added to the outer zone.

I think we can make a conclusion from this that the processes of producing the outer radiation belt of the Earth is not due to the injection of these particles coming from the sun itself. We feel that the material injected into the Earth's exosphere, caught in the magnetic field, is of much lower energy and is not detected by any of these instruments. We feel that we just have a little sniff of it at the very highest energy end. After this material gets into the Earth's field it is accelerated by some process until it appears as the intense radiation in the outer zone.

I think the Pioneer V in space has enabled us to draw conclusions of this type because at the same time we were able to correlate our measurements with Professor Van Allen's group on the Earth's satellite, Explorer VII.

Thank you.

MR. GOETT: Thank you, Dr. Winckler.

As has been mentioned a couple of times, we are fortunate that Explorer VII is in an Earth's orbit during the same time that Pioneer V is out in space. So, in view of the close relationship between the data obtained on Explorer VII and Pioneer V, we have asked Dr. Brian O'Brien, of the University of Iowa, to discuss these results.

DR. O'BRIEN: The information I will present comes from studies by several members of the group at the State University of Iowa. Dr. Van Allen in particular has been studying the events in late March and early April, and correlating with Pioneer V results.

In case you haven't got the information about the Explorer VII satellite readily at hand, I will just mention that it is orbiting between 51 degrees geographic north and 51 degrees south. Its altitude is between 350 miles and about 700 miles.

Even so, just as a satellite is bound to the Earth, while Pioneer V of course is relatively free, we can study the effects of the particles surrounding the Earth in the outer radiation belt once they are affected by the Earth's magnetic field, whereas Pioneer V studies them in interplanetary space when they are again quite free and on their way to the Earth.

I am going to talk, as Dr. Winckler did, about three different types of particles which we detect, and we start from the most Earth-bound outer radiation belt. The particles here are essentially low energy electrons, around about one hundred thousand electron volts. The second group I will talk about are slightly higher energies, these are associated with the Sun. These are what we call solar protons, and we can see them if they have energies above thirty million electron volts.

And also I am going to talk about what are called galactic cosmic rays. These are higher energies still, energies in excess of one billion electron volts.

Firstly, the outer radiation zone, during the quiet period which Dr. Winckler and Dr. Simpson have mentioned, the outer radiation belt, as seen by Explorer VII, was counting along with a maximum counting rate that ran about two hundred counts per second in a fairly lightly shielded Geiger counter on Explorer VII. This value of two hundred a second held fairly steady for a couple of weeks.

Then on the 31st of March the counting rate suddenly went down when the peak magnetic storm came, and the counting rate was at most down to ten counts a second. That is from two hundred down to ten, and it stayed low for some hours. Then gradually in a period of the next week it built up until we were counting something like ten thousand. This is around about April 7 or April 8 that it was counting at ten thousand counts per second, and then it gradually decayed slowly after that. So the three figures are two hundred a second pre-storm, less than ten during the storm, and greater than ten thousand after the storm.

As Dr. Winckler said, since a very similar counter on Pioneer V saw very small fluctuations of similar electrons in outer space, we conjecture four things: First, that the mild burst of activity which was observed by Dr. Winckler, et al., on Pioneer V, represented the direct detection of the incoming plasma cloud.

Secondly, we conjecture that the energy distribution of particles in this plasma was such that it was detected by Dr. Winckler's counter with very low efficiency indeed.

Thirdly, we suggest that a portion of this plasma entered the magnetic field of the Earth, somehow disrupted it so that the trapped radiation which was formerly there was dumped into the atmosphere, causing the low latitude aurora which we observed.

And fourth and finally, we would conjecture that the great subsequent increase in counting rate was due to a local acceleration in the vicinity of the Earth of a portion of the trapped plasma. This acceleration was of sufficiently high energy that our counters could then detect it. I would like to emphasize again, Dr. Winckler has a counter which sees slightly lower energy particles than we do with one of ours.

Next I want to talk about the second group of particles, and that is the group which are classified as solar protons. Continuous watch is being kept for these with Explorer VII when Explorer VII moves to the most northerly and southerly latitudes, North America and south of Australia. We can only pick them up when the outer zone is fairly low and doesn't increase the counting rate at these very high latitudes.

On several occasions since launch solar protons have been detected. I am only going to mention the occasions around the first of April, and the fifth of April, which are associated with Dr. Winckler's and Dr. Simpson's solar protons.

At 1018 through to 1028 Universal Time on the first of April we detected at the highest latitudes counting rates which were of solar protons which were thirty times in excess of the normal cosmic ray rate. On the next pass around, about two hours later, the ratio is about seven to one, and by the next day it was down to less than a half.

On the 5th of April also we saw a rather smaller increase, roughly a two-fold increase.

We are hopeful that by studying the variations in the solar proton fluctuations as the satellite moves to low energy in magnetic latitudes that we can extract some sort of information about the energy spectrum of the solar protons.

And lastly I want to mention the galactic cosmic rays, the effects that we noticed on the satellite, associated with what is called the Forbush decrease. Nature was rather kind on this occasion. We can only detect cosmic rays at very high latitudes if there is no trapped radiation. Similarly so we can only detect solar protons if there is very little trapped radiation.

The trapped radiation was eliminated on the 31st of March. We then saw the Forbush decrease which was seen by the Pioneer V instruments as well.

Once we had a chance to study that in a couple of passes, the solar protons came in, and we had a chance to study those, and then it gradually built up to 150,000 counts a second. So I think all in all we are exceedingly fortunate in a combination of circumstances here. I would like to reinforce what Dr. Winckler said, that simply because we had the Earth-bound satellite orbiting around at the same time as we had the space probe, we are able for the first time to see what is coming in and what is actually happening around the vicinity of the Earth.

Thank you.

MR. GOETT: Thank you, Dr. O'Brien.

Dr. Charles Sonett, of Space Technology Laboratories, will describe for us the results of the magnetometer experiment.

DR. SONETT: Before summarizing the results of the magnetometer experiment carried on Pioneer V, I would like to comment on why such measurements are of scientific interest.

It is not clear what percentage of the energy of the universe is contained in magnetic fields, but there may be a significant portion of the total energy content stored in this manner. A number of astrophysical processes, perhaps most of them, are connected with the behavior of magnetic fields.

An example of a process which is not purely astrophysical but is referenced more to the Earth is the Van Allen radiation.

This radiation, for example, would not exist except for the trapping property, the magnetic trapping property of the Earth's field. I think we can see that the study of the magnetic properties of median around the Earth and in interplanetary space are of direct consequence in the study of plasma. One can consider in fact a magnetometer flight as a plasma diagnostic tool.

In regard to the Pioneer V experiment itself this was a continuation of two experiments which were carried out beforehand, the first one being on Pioneer I, and the second one being on Explorer VI. The equipment was changed slightly but basically the same type of magnetometer was carried. I would like to start on the Pioneer V flight going out from the Earth.

We have reasonable confidence now that we can divide the regions of space around the Earth. The distance out from the surface of the Earth to perhaps five or seven radii seems to have fairly regular properties. True it changes in times of magnetic storm. But we don't seem to see changes larger than a factor of two.

We don't, for example, from Explorer VII, see the classical ring current which exists in storm times. This is very puzzling. When we go out past this region we run into something which has been postulated for perhaps a half century. But on the other hand there has been no experimental evidence.

This is a ring current. On Explorer VI the orbit was designed in such a manner that the apogee, that is the farthestmost portion of the orbit, occurred on the night side, not quite at midnight; somewhere between dusk and midnight. And repeatedly the vehicle passed through the apogee region at about 8:00 to 9:00 p.m. local time on the satellite.

Each time that the vehicle passed through, or almost every time, there was a large anomaly in the field, which I will show you on another chart.

So from these data, from Explorer VI, we were able to determine that there was a large current system flowing on the night side of the Earth. When we flew the Pioneer V flight we got the same sort of perturbations in the field in the daytime, or approximately 3:00 p.m., or approximately 45 degrees from the Earth's Sun line. We know now that the current system closes in an annular manner around the Earth.

It looks something like this. It is centered, at least on the preliminary model calculations, at some ten Earth radii from the center of the Earth and 60,000 kilometers from the center of the Earth. Its extent is some three Earth radii, with the radius of the circle around it.

This current flows, preliminary calculations indicate, something of the order of five million amperes total content. The result of this large current is that the normal dipole field of the Earth is highly perturbed in these regions, and in fact does not have a classical form at all.

So to give you an idea, just for a moment, of the type of thing that was seen on Explorer VI - we will then lead up to Pioneer V - I show you this to show you the similarity between this and Pioneer V.

At the region of some thirty to fifty thousand kilometers on many days there is a decrease in the field, the black dots being the decrease in the field, the black line being the expected value of the magnetic field as seen by the vehicle.

The model calculations we have made is the red line and seems to fit the points rather well considering the simple model that was used. There is another instrument carried on Explorer VI which gives an angle associated with the field, and again the deviations were noted, as much as a hundred degrees from the expected direction of the field, and again the model calculation fits that, so we have two pieces of evidence from Explorer VI indicating a large current system.

On the Pioneer V flight on the way out, we got approximately the same type of signature. There is some difference, to be sure. The field is depressed, 35,000 kilometers from the center of the Earth, crossed, and became larger than normal. The ring flows in a westward direction. It subtracts from the Earth's field on the interior side of the ring. It adds to the Earth's field on the exterior side of the ring. So you see this kind of behavior.

Again this is similar to the sort of behavior seen on Explorer VI. This is now on the daytime side. The ring closes in an annular manner. In fact the model calculations used in Explorer VI seem to fit rather well with the Pioneer V data.

I might add this ring current seems to be a quiet day phenomena. We see it on almost every quiet day. We see it on almost all the days for which we have reduced data from Explorer VI. Pioneer V flew at the tail end of a magnetic storm. The Earth's field was returning to normal. Again we saw it.

Another thing that was seen, this on Pioneer I, was some very peculiar waves in the magnetic field. The consequences of these waves we don't understand yet. It is a rather involved theoretical problem. But these waves were seen from some twelve to fourteen Earth radii, far beyond the point that the Earth's field should have terminated, according to present estimates of such things as the solar wind, which would blow the field in. Again we see the same kind of structure on Pioneer V. Again in approximately the same region.

So to reiterate the statement about the collapse of the field or where the field terminates, where the Earth's field meets the interplanetary field, it does appear that at least on many days the field terminates in something of the order of fourteen radii rather than the classical six to eight radii that has been assumed at present.

When we go out into the interplanetary field -- these are measurements made only on Pioneer V -- there are two distinct types of things that we have seen. The first, the quiet day phenomena, and then I will go to the storm phenomena that you see here.

As far as quiet day phenomena is concerned, there is definite evidence by now -- the vehicle has been in orbit about the Sun for a sufficiently long period of time -- we have definite evidence that there is a steady field in space. This is not surprising. But what is surprising about it is that it seems that this steady field makes a large angle with the orbit of the Earth. That is, with the plane of the ecliptic. This is the plane which contains the orbit of the Earth about the Sun. This is somewhat surprising in view of other things that must happen in the interplanetary medium with regard to plasma in particular.

So much for quiet day field. One more comment about this. We can only conjecture as to where this field originates. One possibility of course is that it is a galactic field, permeating the solar system. There are serious objections to this notion however. In fact there are serious objections to making this field occur in any way that we can think of now.

As far as the storm time field is concerned, this is perhaps one of the most interesting things that we have seen. There is direct correlation between the happenings in space, some three million kilometers from the Earth, and what happens on the Earth. There is in fact a proportionality between the effects on the Earth and the effects in space.

There is no evidence from Explorer VI that a ring current flows during storm times. This does not rule out the possibility that a ring does exist during storm times and supplies the decrease in the field that is now classically noted. However, we have not seen it.

Since we did not see this, we have to ask the question of where does the decrease, the main phase decrease of the storm originate, how does it take place. We can only say the following now: We can say that there is a direct interaction between the magnetic field in interplanetary space, a kind of storm out in space, and what happens on the Earth. In other words, it is nothing like plasma coming into the field and forming a ring. There is a direct electromagnetic interaction.

I have one slide which shows this a little more clearly.

(Slide.)

This is information obtained from Fredericksburg. This is called the "a" index, a measure of the activity on the surface of the Earth. You will note that there is a remarkable agreement in time between the disturbance averages on the surface of the Earth and the disturbance average during the large solar disturbance that Dr. Simpson and Dr. Winckler and Dr. O'Brien discussed before. This is the time of that very large solar event.

The magnetic records for the surface observatories have just been checked, and they agree, in fact in detail, with what is happening out there. This is very surprising. So we feel that the evidence is strong enough to question whether magnetic storms on the Earth, the classical type of magnetic storm, occurs in exactly the manner that theory has indicated for years.

This is perhaps one of the most surprising things that has come out of the magnetometer data. So to summarize, I think we see that the Pioneer V flight has done two things: It has corroborated and extended data that has been obtained from the Pioneer I, and Explorer VI flights, and in addition to that it has supplied new and valuable information pertaining to the interplanetary medium itself.

Thank you.

MR. GOETT: Thank you, Dr. Sonett.

Now Mr. Maurice Dubin, of NASA Headquarters, will describe to us the results of the micrometeorite experiments.

MR. DUBIN: This is a different type of experiment that I should be describing. In this experiment the experiment was designed to measure the solid component of material in interplanetary space. We call these micrometeorites. We also call it microdust.

The experiment is a continuation of earlier experiments beginning with Explorer I. Some measurements have been made on satellites around the Earth, on various satellites, and also deep space probes like Pioneer I.

The particular experiment is a joint experiment beginning at the Air Force Cambridge Research Center and continuing with them, when some of the people who were involved transfered to NASA.

The type of experiment is such that the small dust is measured by detecting the acoustical vibrations, the vibrations on impact of the surface of the meteorite. A special plate is calibrated, using a piezo-electric crystal, or microphone, fed into an amplifier and then fed into the telebit unit for storing the information.

Two levels are recorded on the telebit unit. The one level, assuming a momentum dependence and a velocity of 30 kilometers per second, should detect particles as small as 10^{-10} grams. The second level, or the "b" level, would detect particles roughly ten times the mass of the "a" level.

If you have handy your press release, on Page 3 there is a table which describes the results of the count on Pioneer V. This is the press release titled "Pioneer V Micrometeorite Measurement, 60-180."

The first date listed is 11 March, with the time roughly about launch, showing the "a" and "b" scales. The numbers here are coded and the "a" scale is a measure of the count at the time given. By subtracting that from a later count one gets a scaling factor for the "a" count. That number is multiplied by four to get the actual count.

The "b" scale is done in a similar fashion. Whereas the "a" scale recycles at 127 to 000, the "b" scale recycles after 7 to 0, and the scaling factor for the "b" unit is 2.

Noting that, one notes that from the 11th of March to the 14th of March there is no change whatever on the counter. This would mean that on the "a" scale three or less impacts were recorded on the vehicle for the first three and one half days.

On the 14th of March, about 36 seconds after the last reading given, the "a" scale changed to a value of 127. This represents, with a scaling factor of 4, 328 impacts in a period of only 36 seconds. This is really untenable in the physical sense and gives one the feeling that possibly the equipment is not functioning correctly.

Following that, for the next six days, to the 20th of March, no more impacts were recorded.

On the 20th of March there is a recycling of the "a" scale, reading 000, which is again equivalent to up to four impacts.

Beginning on the 27th of March, seven days later -- in the seven-day interval again no counts, meaning less than four impacts, were recorded. The counter begins counting for the next few days. That is through the 29th of March.

Here, if everything is working satisfactorily, an impact rate of 1.5×10^{-3} per square metters per second was recorded.

Subsequent to that, the "b" scale, the larger particles, went through a number of impacts, showing between 13 and 15 impacts in a very short time, and then on the 18th of April there was this other catastrophic event of a large number of impacts on the "a" scale. Something of the order of 500 impacts occurred.

The overall conclusion from this is that there is serious doubt as to the operation of the equipment, and in particular because the difference in impact rates compared to the design criteria and the earlier measurements that we have lead to the situation that the information to date would have to be discounted on scientific grounds.

I think that is all I have to say on it.

MR. GOETT: That concludes our formal presentation. I will turn it back to you, Herb, for questions.

MR. ROSEN: Ladies and gentlemen, we have been at it for an hour and twelve minutes. We now throw it open to the floor for questions and answers.

QUESTION: I wonder if Dr. Winckler could give us an idea of the intensity in roentgens per hour of this radiation that he mentioned.

DR. WINCKLER: Between five and fifty is inferred. The directly-observed event was about forty milli-roentgens per hour in Pioneer V. The preferred value is for the most intense event we know of, which occurred last July.

QUESTION: Is that higher than the figure you estimated originally from the balloon?

DR. WINCKLER: Lower.

The reason is that we found the spectrum apparently cuts off at around forty million electron volts. I would like to emphasize that these numbers are very tentative because each of these events may differ. We don't measure all the details of each event. We can only guess at what might have been. This event we have covered extremely well.

QUESTION: Might the speaker on micrometeorites care to guess, or know, where the failure in the counters occurred; whether it was in the telemetry converter?

MR. DUBIN: This is a little bit hard to do because you can't examine the equipment. There is one possibility, at least where the count goes very high and goes to the full count on the counter, the 127 figure on the table, that there could be binary digits stuck in the unit position, so that when the shift register operated it filled it up. That is about the only guess that we can put out at this time.

QUESTION: I would like to ask Dr. Winckler what is the possibility of shielding against these radiations.

DR. WINCKLER: That is a very complicated question. It depends on emission and risks that you are willing to take. I don't think there is a clear answer.

QUESTION: I don't want to take any risks.

DR. WINCKLER: Other risks are much greater, I would say.

QUESTION: Dr. Sonett referred rather briefly to the apparent coincidence of fine-scale magnetic variations on Pioneer V, and those on the Earth, which is a rather startling thought. I wonder if he could enlarge on that a little bit, particularly the time relationship.

DR. SONETT: It would be difficult for me to give you any detailed information since the correlations were done this morning at the Commerce Department. But we are very surprised and very pleased with the way the information does correlate.

QUESTION: On what sort of a time scale are the changed relationships? In hours, days, minutes?

DR. SONETT: Certainly in a matter of hours, not days.

QUESTION: I was going to ask Dr. Sonett if this suggests the possibility sometime of sending satellites out to considerable distances to forewarn us of solar flares so that maybe we can do something about communications on Earth?

DR. SONETT: I suppose in principle you could do that, yes, because the velocity of propagation is much less than that for a radio wave. So this means that you could sit out a ways from the Earth and get a message to the Earth before such a thing arrives. But I am not sure that this would be a desirable thing to do.

QUESTION: Dr. Sonett stated that this agreement between magnetic field in space and on Earth cast doubt on the theory of magnetic storms as it now exists. Could you elaborate on that a little?

DR. SONETT: I have to be very careful there, of course, because this is hallowed ground. All I can say is that there are some puzzling data. We have not seen the classical storm ring at the radius that various theoreticians estimated it should exist. This is for the storm of the 16th of August last year, when Explorer VI was flying. Again now, with the very good correlation between the interplanetary electromagnetic state, some millions of kilometers from the Earth, and the data obtained on the ground for the storm of March 31, 1960, this would indicate that something has taken place which is not a two-step process; whether there is a lot lost in the fine structure between the two processes.

QUESTION: What was the date of this correlation in magnetism and the distance of the vehicle at that time, roughly?

DR. SONETT: It was the 31st of March storm. In the region around the 31st of March there was a very large solar event.

QUESTION: And the distance then was what?

DR. SONETT: Approximately three million miles.

QUESTION: One more question. As I understood it earlier, the ring current lay at the outer fringe of the outer radiation belt, but the illustration you showed showed it much further out. Can you explain that?

DR. SONETT: The model calculation, which is admittedly over-simplified but gives a very good picture, indicates that the center of the course is ten Earth radii from the center of the Earth. Its radius, that is if you cut it, slice it open with a knife and look at a circular cross-section, its radius is three Earth's radii. Which means it would be from 7 to 13 Earth radii. This is out past the heavily trapped radiation belt, outer belt.

QUESTION: Is it on the outer fringe of it or is it well beyond?

DR. SONETT: This is a very nice picture here, but I wouldn't be surprised if this current tapers off in some manner. It certainly isn't as sharply delineated as the artist's conception gives it here. It may be that one merges into the other. We don't know that yet.

QUESTION: Could you give us an idea of how much 5,000,000 amperes is? I am sorry, I don't know.

DR. SONETT: This is a difficult question to answer, again because this is a kind of an Alice in Wonderland world, these large-scale plasmas. They are very highly conducting. You can't support an electric field, a voltage across them. It will short out. So you may have millions of amperes flowing but not an awful lot of energy. In fact, this is a rather delicate thing, this ring.

QUESTION: Dr. Simpson, in your first slide you showed a solar flare causing a Forbush decrease. This is in the proton count. The second flare showed an increase in that same graph. Does this mean the two flares were different in nature? How do you account for this?

DR. SIMPSON: I might try to ask the question again. The question is, out of all the solar flares we showed two on that first graph. The first one we claimed was the origin of this plasma cloud that eventually got to the vicinity of Pioneer V and the Earth and produced the effects we are discussing here today. And then the second one shown led almost immediately to the arrival of fast particles. It is likely that both of them accelerate particles, but it is suggestive that during the time that the second one arrived that the solar protons found their way easily to the Earth, and quickly, because you may have swept out the magnetic fields and made it much easier for the particles to excape.

There is evidence, I think Dr. Winckler will concur in this, of lower energy radiation at the time of the flare on the 30th. I think this is true. We see a small increase there, but it certainly was not the outstanding event.

QUESTION: Dr. Winckler spoke of definite biological effects from some of these intense radiations. Was he speaking of biological effects to people on Earth or people flying through space?

DR. WINCKLER: It is not of any concern to people on Earth because these particles don't reach the surface. They are found only at a depth of 50,000 feet in the atmosphere, no lower.

QUESTION: I don't know to whom to direct this question because it really bears upon all three of the radiation experts.

There is a hypothesis that the outer belt is produced by cosmic ray neutron decay, which is a sort of rival to the more accepted view that it is fed from the sun. Have the Pioneer V results, combined with Explorer VII results, eliminated that hypothesis?

DR. WINCKLER: First of all, it is not directly from the sun. I think that is one thing.

Secondly, the intensities and their rapidity of change seem to indicate that it is difficult to account for it by neutron decay. This is a topic which is under discussion now.

MR. ROSEN: Dr. Simpson?

DR. SIMPSON: I might say it would be highly unusual for nature to suddenly become very simple. First of all, we know that the neutrons are decaying out there; that there is a certain amount of the radiation that is trapped electrons. But the fundamental question is whether it isn't true that there is just one dominant process, suggestive of their being only one dominant process, and because of the large-scale changes in energy that Dr. Winckler mentioned it seems hard for a weak source of neutrons to keep building up at a sufficient rate to keep the region alive.

QUESTION: Dr. Winckler, you stated there were between five and fifty roentgens per hour in the most intense flare event. What was the shielding that you were referring to?

MR. ROSEN: Do you mean the shielding around the instruments?

QUESTION: If you were referring to five to fifty roentgens.

DR. WINCKLER: This is an event which was supposed to have taken place in space last July. It is not directly observed in space. It was observed in balloon measurements.

MR. ROSEN: I think the question was as to the shielding around the instruments.

DR. WINCKLER: The shielding around the instruments in Pioneer V, as detected in the smaller events just shown, was from a half to five grams of material. That is equivalent to a half to five centimeters.

QUESTION: Would it be too much to ask if someone would draw a picture on the blackboard of the relationships between the solar flares, the magnetic fields, and the Van Allen layers?

MR. ROSEN: This gentleman wants a composite picture of what he thinks we have discovered, simplified. Is there any simplification of this?

DR. SIMPSON: You could only just sketch.

MR. ROSEN: You could probably do it on a scale.

Is that what you mean, on a distance scale from the Earth?

QUESTION: More or less. Just a sketch.

DR. SIMPSON: Let's assume that the distance across the blackboard represents the sun-Earth distance at any given time. The time we will pick is a period around the 31st of March to the 1st of April, so it will pile on all the events.

Here is the sun. We are now taking a view, taking a cross-section so that there is almost the plane of the ecliptic. We will put the Earth out here, and we will place the outer radiation belt something like this. This region at H-15 would appear here, on the Northern Hemisphere of the sun. The sun has a coroan which goes out many times its own radius where it is effective for storing particles and accelerating particles.

Without going into details, on the 31st there was some type of ejection of matter -- that originally belonged to the sun -- into space. This probably contained also magnetic fields, although we are not sure of the nature of them, and we don't know whether it was an enclosure that was empty inside or whether it was solid or any of these features.

We also don't know what this did to the magnetic fields that were already present that Dr. Sonett was measuring when everything was quiet. But it certainly was pushing them around.

So one might imagine, without drawing an artist's conception, that there were magnetic fields already in space of weak character. We don't know whether they had a strong radial component, whether they were dipole or what. We will not answer that right now, but that there is a field present. And this medium passing through it certainly squeezed the prevailing field. That is the second thing that we are pretty sure of.

This region, reaching the vicinity of the Earth then, at a later time, this plasma, certainly by Earth dimensions, was enormous, and certainly collided with the magnetic field. The magnetic lines of force of the Earth, however, couldn't immediately penetrate this because this is a very highly conducting medium.

And so it was as though the Earth's system had been hit by a solid object, so to speak, so the Earth's field would flux and change form.

In here, then, would be the phenomena of Dr. Winckler's and Van Allen's proposal for the spiraling low-energy particles getting dumped first when the fields were shaken up. They could no longer be retained on the lines of force, and the aurora was seen. And then, as this plasma kept streaming in, it formed interstitially in the lines of force the plasma, it is being argued, to be accelerated later by some mechanism unknown, to then build up relatively high-energy particles into the outer radiation belt.

Is that a fair statement of that part of the picture?

MR. GOETT: A remarkable statement.

DR. SIMPSON: At the same time we have had Pioneer V out here, and let me now pretend that I have let the cloud advance, but I will change my coordinates and move Pioneer V out here so that it is inside this region.

Just before this advanced, coming from the galaxy was a cosmic ray flux, a flux of cosmic ray particles, from all directions. There was a certain intensity, so many counts per second of cosmic rays, that because of this region moving forward and distortion of the prevailing field, and this field going in the plasma, the particles found themselves being deflected and scattered, and having to weave this way by scattering in magnetic fields into this inner region. So that for an appreciable period of time the intensity inside this region was less than out in the galaxy. And in fact, by reversing the argument, by saying that we can prove that this is it, one can argue that there is something of this general type going on.

So we see now the interrelationship of the galactic cosmic rays, the depression, and advancing plasma region of hot gas at high temperatures, and collision with the magnetic field, and these interactions.

That is about as general as one can get.

QUESTION: Where is the ring current?

DR. SIMPSON: About ten Earth radii about a good medium point. Out here and here there is circling this very tenuous charged particle stream that essentially, if you looked at it cross-section, represent only a few particles per square centimeter, but looked at in total cross-section represents a million amperes or more current.

It would be interesting to know whether that is destroyed temporarily when all of this occurs.

MR. ROSEN: I have to assume that answers your question.

QUESTION: Yes, it does.

MR. ROSEN: I also have to assume that, since it is after 1:30, that this conference has now drawn to a close.

(Thereupon, at 1:35 p.m., the press conference was concluded.)

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SCIENTIFIC ORGANIZATIONS AND THE DEVELOPMENT OF INTERNATIONAL LAW

Remarks By
JOHN A. JOHNSON, GENERAL COUNSEL
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
At a Panel Discussion On "The Role Of Nongovernmental Groups In The Development Of International Law"
At The Annual Meeting Of
THE AMERICAN SOCIETY OF INTERNATIONAL LAW
Washington, D. C., April 29, 1960

This is the era of Science. Our every day speech reflects it. In our own century, the Age of Electricity, the Air Age, the Atomic Age, and, finally, the Space Age have succeeded each other with bewildering rapidity.

The structure of our own Government also reflects it. No one doubts the dependence of our national security, health, and welfare on the advancement of science. In the years since World War II, the Atomic Energy Commission, the National Science Foundation, and the National Aeronautics and Space Administration have all been established; and the scientific programs of many other agencies have been greatly enlarged. Ten years ago the Office of Science Adviser was established in the Department of State, and science attachés have since been appointed to several of our Embassies abroad. Today the President has a Science Advisory Board, a Special Assistant for Science and Technology, and a Federal Council for Science and Technology.

On the nongovernmental level, science is also a highly organized activity. In addition to numerous associations of scientists concerned with particular disciplines, science has a very articulate spokesman in Washington in the National Academy of Sciences. Incorporated in 1863 by a special Act of Congress, it is required by the act of incorporation to respond to the request of Government departments to investigate, examine, experiment, and report upon any subject of science.

In the light of all this, one might be inclined to assume that nongovernmental scientific groups have had an influence on the development of international law comparable to their influence on other phases of the contemporary social and political order. My own opinion is that this has hardly been the case.

The progress of science undoubtedly has had a substantial effect upon international law and organization. Numerous international conventions have been adopted and international organizations established that would have had no reason for existence were it not for the level of scientific activity of recent years. Science and technology have created new conditions in world-wide transportation, communications, meteorology, and many other fields that have made it necessary or expedient for governments to create new forms of organization and new international legislation to cope with them. The moving force, however, appears to have been scientific progress itself, and its economic and social consequences, rather than the deliberate efforts of nongovernmental scientific groups.

I know that such a generalization is subject to many exceptions; but I think it is safe to say that, in comparison with the organized efforts of labor and commercial organizations, the conscious contributions of scientific organizations to the development of international law has been rather small.

Times are changing, however, in this respect as in many others. Scientific undertakings have been organized and conducted on a global scale never before attempted. New kinds of scientific activities have come to the fore which cannot be contained within national boundaries. New situations and new problems have thus been created which the scientific community itself recognizes as requiring solutions of a legal nature on the intergovernmental level.

I think the most instructive case in point is the recent history of the International geophysical Year and its immediate consequences. But before dealing with that subject, let us consider briefly the international organization of the scientific community today.

As everyone knows, the progress of science and technology was phenomenal during the last half of the Nineteenth Century. So was its international organization. Cooperation among scientists and scientific groups on an international basis became indispensable to the progress of certain of the physical sciences in particular. Geodesy and meteorology were conspicuous examples. It is not surprising that the first international organization of scientists to enjoy a long life was the International Association of Geodesy founded in 1864. The work in which it was interested required international standardization of measurements, and this led to the formation in 1875 of the International Bureau of Weights and Measurements. A number of other international scientific organizations followed. Some were formed to advance science by direct cooperation across national boundaries, and others were designed to encourage the exchange of views and the dissemination of information by such means as international scientific congresses.

A striking instance of early international scientific cooperation was the International Polar Year in 1882-83. In 1879, the International Meteorological Congress endorsed the idea of an International Polar Year for the purpose of establishing rings of stations as close as possible to the Arctic and Antarctic Circles to make synchronized observations, primarily of weather and the earth's magnetism. Eleven nations participated in this great enterprise, which set a pattern repeated 50 years later in the Second International Polar Year, in 1932 and 1933, and again, most recently, in the International Geophysical Year in 1957 and 1958. The second International Polar Year, like its predecessor, was organized under the auspices of international scientific bodies that were forerunners of the World Meteorological Organization.

In 1899, the French, Italian, Russian, and United States Academies of Science agreed to form an international Association to be called the International Association of Acadamies. It held its first meeting in Paris in 1900.

Largely because of the effect of World War I in interrupting meetings of the International Association of

Academies and many other international scientific organizations, a reorganization took place in 1919. At that time a new organization, the International Research Council, was formed for dealing with matters of international scientific interest and to facilitate scientific undertakings requiring international cooperation. A number of international scientific unions were also formed at that time. Originally affiliated with the International Research Council were the International Unions for Astronomy, Geodesy and Geophysics, Chemistry, and Mathematics. To these were later added Scientific Radio (1921), Physics (1922), Geography (1923), Biological Sciences (1922), Crystallography (1927), Theoretical and Applied Mechanics (1947), History of Science (1947), Physiological Sciences (1955), and Biochemistry (1955).

The International Research Council retained considerable control over the Unions. Its statutes provided that it should "initiate" and "direct" various international scientific programs. Differences of opinion about these and other matters led to a reorganization in 1931 by which the IRC was transformed into the International Council of Scientific Unions (ICSU). The new organization became essentially a federation of autonomous Unions.

ICSU is made up of two types of members: first, National Members consisting of National Academies of Science or comparable bodies representing 45 nations; second, Scientific Members consisting of 13 International Scientific Unions. The General Assembly, which is the governing body of ICSU, is composed of representatives of both the National Members and of the Scientific Members. Although some of the National Members are governmental or quasi-governmental, ICSU is essentially a nongovernmental body. UNESCO provides a parallel organization at the intergovernmental level.

The Statutes of ICSU provide that its chief objects are:

"(a) to coordinate and facilitate the activities of the International Scientific Unions in the field of the Natural Sciences;

"(b) to act as a co-ordinating centre for the National Organizations adhering to the Council."

Further objects of the Council include encouragement of international scientific activity in subjects which do not fall within the purview of any existing international organizations and, of particular relevance to the subject of our discussion, the maintenance of relations with the United Nations and its Specialized Agencies.

In 1951, ICSU commenced planning for the International Geophysical Year. In 1952, it issued invitations to nations adhering to ICSU to join the effort. Since the Soviet Union was not at that time a member, a separate invitation was sent to the Soviet Academy of Sciences. Here we have a striking instance of an international scientific organization, operating on the nongovernmental level, initiating with relative ease a program of world-wide activity which undoubtedly would have been much more difficult for governments themselves to accomplish.

In 1953, ICSU formally established the Special Committee for the International Geophysical Year (known as CSAGI from the initials of its name in French). It was not until CSAGI's meeting in Rome in the fall of 1954 that notification of the Soviet Union's intention to participate was received. At that same meeting, CSAGI passed a truly historic resolution urging that as many nations as possible consider developing scientific earth satellites to be launched during the International Geophysical Year. The resolution stated:

> "In view of the great importance of observations during extended periods of time of extra-terrestrial radiations and geophysical phenomena in the upper atmosphere, and in view of the advanced state of present rocket techniques, CSAGI recommends that thought be given to the launching of small satellite vehicles, to their scientific instrumentation, and to the new problems associated with satellite experiments, such as power supply, telemetering, and orientation of the vehicle."

Within a year, both the United States and the USSR indicated their intention to launch satellites as part of the IGY effort.

The tone of the entire IGY effort was set by ICSU's insistence on free and prompt dissemination of information. It was agreed from the start that the data gathered during the IGY would be available to the scientists of all nations. This applied to research utilizing satellites as well as to other IGY activities, and appropriate resolutions to that effect were adopted by CSAGI.

The accomplishments of the IGY are so well known that it would be pointless to recount them here. It is important, however, to note that the work was planned under the guidance of a nongovernmental international scientific organization and accomplished through the voluntary cooperation of scientific groups in some 66 countries, also largely nongovernmental in character. Each of these groups, in turn, decided on its own participation in the program and obtained the necessary financial and logistic support from its national government.

The IGY has had spectacular international legal consequences. In the first place, highly successful cooperative efforts of many nations in the Antarctic during the IGY set the stage for the Antarctic settlement. That the spirit of IGY cooperation keynoted the Antarctic negotiations is evident from the text of the United States Note of May 2, 1958, addressed to the Foreign Ministers of the 11 other countries which had carried on scientific research programs in Antarctica during the IGY. The Note, after referring to "the splendid example of international cooperation which can now be observed in many parts of the world because of the coordinated efforts of scientists of many countries in seeking a better understanding of geophysical phenomena during the current International Geophysical Year," stated in part:

> "The International Geophysical Year comes to a close at the end of 1958. The need for coordinated scientific research in Antarctica, however, will continue for many more years into the future. Accordingly it would appear desirable for those countries participating in the Antarctic program of the International Geophysical Year to reach agreement

among themselves on a program to assure the continuation of the fruitful scientific cooperation referred to above. Such an arrangement could have the additional advantage of preventing unnecessary and undesirable political rivalries in that continent, the uneconomic expenditure of funds to defend individual national interests, and the recurrent possibility of international misunderstanding. It would appear that if harmonious agreement can be reached among the countries directly concerned in regard to friendly cooperation in Antarctica, there would be advantages not only to those countries but to all other countries as well."

I think we can agree that it is quite inconceivable that the Antarctic matter would stand where it does today were it not for the IGY. Yet it must be noted that the scientific groups which were responsible for setting the stage had little, if anything, to do with carrying the action forward on the political and legal level. In fact, the whole IGY effort was studiously nonpolitical.

Even more dramatic were the consequences of the IGY in the field of outer space. For several years preceding the launching of the first IGY satellites, a number of new international legal questions had been foreseen by legal scholars. Immediately after the first Sputnik, however, these questions became the subject of popular debate, press comment, and Congressional attention.

On December 13, 1958, the General Assembly of the

United Nations Adopted a resolution establishing an Ad Hoc Committee on the Peaceful Uses of Outer Space. It was directed to report to the General Assembly on several matters, including "the nature of legal problems which may arise in carrying out programmes to explore outer space."

In the interest of brevity, I shall refer to only one of the subjects covered in the legal section of the Committee's report. That is the one concerning the question of the freedom of outer space for exploration and use.

While the IGY was still in progress, the Legal Adviser to the State Department had argued "that the only conclusion that can be reached with respect to the arrangements regarding the International Geophysical Year is that there is an implied agreement that, for the period of the International Geophysical Year, it is permissible to put into orbit satellites designed for scientific purposes." The "implied agreement" was evidently found in the fact that no nation had protested the announcements of the United States and the Soviet Union of their intention to launch earth satellites during the IGY. The Legal Adviser concluded, "Once the year is over, rights in this field will have to be determined by whatever agreement may be reached with respect to such objects."

The report of the United Nations Ad Hoc Committee, issued in July, 1959, noted that during the IGY, and subsequently, "countries throughout the world proceeded on the premise of permissibility of the launching and flight of space vehicles which were launched, regardless of what territory they 'passed over' during the course of their flight through outer space," and concluded, "The Committee, bearing in mind that its terms of reference refer exclusively to the peaceful uses of outer space, believes that, with this practice, there may have been initiated the recognition or establishment of a generally accepted rule to the effect that, in principle, outer space, on conditions of equality, is freely available for exploration and use by all in accordance with existing or future international law or agreements."

Since the Ad Hoc Committee's report was rendered, space activity has been considerably stepped up. At the present time, a total of 22 earth satellites have been placed in orbit, 18 by the United States and 4 by the Soviet Union. These satellites have repeatedly passed over the territory of every nation on earth. No permission was sought in advance; none was expressly given by any State; and not a single protest has been registered by any State.

The cautious language of the Committee hardly seems necessary today. I would suggest that a new principle of international law has already been established by the actions of the great powers engaged in this activity and the unanimous acquiescence of all other States. This principle is that outer space is not subject to claims of territorial sovereignty, that no State has the right to exclude other States from the use of any part of it, and that it is therefore freely available for exploration and peaceful use by all. This new principle is the direct result of activity initiated during the IGY. Here again, however, international law is developing as the result of scientific activities planned by nongovernmental groups -- not because of the conscious concern of such groups with the development of international law.

With the termination of the IGY and the completion of CSAGI's work, ICSU established several special committees to continue a program of international scientific cooperation. One of these is the Committee on Space Research (COSPAR), composed of representatives of nine International Scientific Unions concerned with major fields of science benefiting from space research and representatives of the international scientific institutions of a number of countries engaged in launching rockets and satellites or in tracking space vehicles.

COSPAR was established by a resolution of the ICSU General Assembly in Washington in October, 1958, stating that it was the primary purpose of COSPAR "to provide the world scientific community with the means whereby it may exploit the possibilities of satellites and space probes of all kinds for scientific purposes, and exchange the resulting data on a cooperative basis." The Committee was also given the following directions which are relevant to our discussion:

> "The Committee shall hold as a primary objective the maximum development of space research programs by the international community of scientists working through the ICSU and its adhering national academies and unions. Recognizing, however, the need for international regulation and control of certain aspects of satellite and space probe programs, the Committee shall keep itself fully informed on United Nations or other international activities in this field, in order to assure that maximum advantage is accorded international space science research through such regulations, and to make recommendations relative to matters of planning and regulation that may effect the optimum program of scientific research."

COSPAR, accordingly, has closely followed United Nations developments in the field of space activities and has adopted resolutions formally offering its services to the U.N. and instructing its President to furnish information on its activities to the U.N. Secretary General. On the U.N. side, COSPAR's President was invited for consultation when the U.N. Ad Hoc Committee on the Peaceful Uses of Outer Space met last year.

One of COSPAR's working groups is concerned with the tracking and transmission of scientific information. This group immediately took cognizance of the importance of radio frequency allocation to the success of space research, a problem which the U.N. Ad Hoc Committee had recognized as a most urgent one. On the advice of this working group, COSPAR made a strong presentation to the Administrative Radio Conference of the International Telecommunications Union in Geneva last fall of both the immediate and long-term needs for allocations of exclusive radio frequencies for the purpose of space research, and made specific recommendations for such allocations.

The Conference had fruitful results. Special radio bands were fully or partially reserved for space research in the regulations adopted by the Conference. These regulations, which are due to become effective on June 1, 1961, are an annex of the International Telecommunications Convention which has already been adhered to by over 80 nations, including the U.S. and the USSR. Moreover, the Administrative Radio Conference recommended the holding of an Extraordinary Administrative Radio Conference during the latter part of 1963 to deal with the question of allocation of radio frequencies for space research in the light of new developments.

At its last meeting in Nice in January, 1960, COSPAR adopted a resolution noting its appreciation of the work of the ITU Conference and recommending "that the collaboration of COSPAR and the ITU should continue and be used to the fullest extent to promote international coordination of the use of the radio frequency spectrum for space purposes."

I am sure that there are other international scientific groups which are actively contributing today to the development of international law and organization. I have cited COSPAR because it is the organization which is most closely related to our work in NASA and because I think its activity during the past year is a good example of a greater degree of involvement of scientists in the processes of international organization on the political and legal level than has characterized them in the past. This involvement may not be desired by the scientists themselves, but it seems inescapable because of the very nature of the activities which they have set in motion. The successful conduct of scientific projects in certain fields today demands a degree of regulation and control which can only be accomplished at the intergovernmental level and through the means of international organization. In view of these developments, I think it is safe to predict that nongovernmental scientific groups will find it increasingly in their interest to participate actively in efforts to arrive at solutions of a legal nature which are not only acceptable, but positively desirable, to them.

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No. 60-179

Prepared for The American Geophysical Union Meeting
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PRELIMINARY RESULTS FROM THE SPACE PROBE PIONEER V UNIVERSITY OF CHICAGO EXPERIMENTS*

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The space probe Pioneer V was launched March 11, 1960 into an orbit around the Sun and inside the orbit of Earth. The scientific apparatus included instruments identical with the University of Chicago apparatus used on Explorer VI[a]; namely, energetic particle detectors which measure fluxes of protons with energies greater than 75 Mev, electrons with energies greater than 13 Mev, and the bremsstrahlung from electrons and gamma rays of lower energy. Simultaneously with the measurements in Pioneer V a series of four neutron monitor piles were recording the changes in cosmic radiation intensity at the Earth. We report here on some preliminary results obtained from the Chicago experiments during the time within which Pioneer V traveled to a distance of approximately 8×10^6 km from Earth. Beginning 20

March solar activity rapidly increased with many solar flares, radio noise bursts, etc. over a period of 10 days. Most of our results relate to this period.

1. Experimental tests to identify the electromagnetic modulation mechanism for the sudden decreases of galactic cosmic ray intensity (Forbush type decreases) have been discussed in a recent paper[b] reporting the results from Explorer VI wherein it is shown that out to distances greater than eight earth radii this phenomenon is of the same magnitude as observed at the Earth. On March 31, 1960 a similar type of decrease occurred at the Earth and at Pioneer V. The decrease at 5×10^6 km from the Earth was at least as great as at the Earth. Hence, existing theories for this phenomenon requiring the presence of the Earth and its magnetic field are proved to be invalid.
2. The direct detection of particles accelerated in solar flares was observed in Pioneer V. (a) The most outstanding event occurred April 1, 1960 where not only protons but electrons and/or gamma rays from the Sun were found. (b) Another consequence of this event follows from the reported polar cap absorption of radio noise (H. Leinbach, private communication) in coincidence with the increase

of particle flux at the position of Pioneer V. This shows that the solar flare particles producing the ionization in the polar atmosphere for many hours are not stored in the geomagnetic field, nor at the Sun.

3. Evidence has been found for the solar production of energetic electrons by processes other than solar flares. Bremsstrahlung was measured in Pioneer V for many days of the period over which data ave available at present.

The apparatus is composed of a triple-coincidence counter system surrounded by 5 mm of lead. The instrument is so designed that high energy charged particles may be measured separately from the large background of low energy particles. The experimental apparatus is composed of many circuits, including information-storage circuits capable of providing data on both the high energy radiation and the low energy radiation. The information is relayed by two telemetry channels from the space probe to the earth upon command from the earth.

Since the objectives of these experiments include the detection of particles accelerated to high energies at the time of unusual solar events, and a search for solar particle streams or giant plasma clouds, a temporary 24-hour watch has been established at the Fermi Institute to receive data from stations over the world observing solar, and solar-related phenomena. The Institute's network of cosmic ray stations extending northward from Peru continues through this period as part of the experiment. In case an unusual event, such as a giant flare, is detected, communication channels are available whereby the earth-stations for recording telemetry signals from Pioneer V will be alerted to obtain additional data at these special times.

These experiments are being carried out by Peter Meyer and J. A. Simpson of the University's Enrico Fermi Institute for Nuclear Studies, and by C. Y. Fan and the engineering staff of the Chicago Midway Laboratories, a division of the University's Laboratory for Applied Sciences.

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[a] Fan, Meyer and Simpson, Proc. of the First International Space Science Symposium, North Holland Pub. Co., Amsterdam (1960) (in press).

[b] Fan, Meyer and Simpson, Phys. Rev. Letters 4, 421 (1960).

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PIONEER V MICROMETEORITE MEASUREMENTS

An experiment to measure the distribution of cosmic dust in the ecliptic between the orbits of Venus and the earth was carried in the payload of Pioneer V launched on 11 March 1960. Impacts of micrometeorites on an acoustically isolated surface of 0.04 square meters area were detected by means of a piezoelectric transducer. The pulsed signal from the transducer was amplified and shaped and two separate pulse amplitudes were stored on the Pioneer V "telebit" unit. The threshhold pulse level "A" was sensitive to impacts of dust particles with masses greater than 1.2×10^{-10} grams as estimated from a momentum calibration and an average impact velocity of 30 km/sec. The "B" threshhold level was 1.7×10^{-9} grams. From the "A" and "B" data the mass distribution of cosmic dust could be computed. Preliminary data from the experiment has been received for the interval from 11 March through 24 April 1960. Apparently the experiment is not operating satisfactorily as evidenced from the data which indicates that no impacts (actually three or less) were recorded during the first three and a half days after launch, and that there were two cases of erratic operation resulting in counter saturation. The experiment appears to have functioned between 27 March and 2 April. The available data and a preliminary analysis is given below.

The two counters in the "telebit" unit recorded data using a binary system. Counter "A" which recorded both "A" and "B" levels used a scale of 4 and could count to 127 before recycling after a total of 512 pulses. Counter "B" was on a scale of 2 and recycled after 16 "B" pulses. Both storage units showed multiple counts during the launch phase including payload and third-stage separation. This was expected. After injection the "A" counter reading was 045, and the "B" counter reading was 7. Table I is a tabulation of counter readings from injection on 11 March through 24 April 1960. All data points showing a change in counter readings are tabulated.

From the time of injection until 2240 on 14 March, a period of three and a half days, no change in count was recorded. An impact rate corresponding to that on Pioneer I, which resulted in the relatively low level impact rate of 4.0×10^{-3} impacts meter^{-2}sec^{-1}, would have yielded 24 impacts or a count of 6 on the "A" counter for similar sensitivity. The space density of cosmic dust near the earth may be larger than in interplanetary space because of the effect of the earth's gravity, and the trajectory of Pioneer I was similar to Pioneer V during the first few days.

At 2241:11 on 14 March in an interval of 36 seconds the "A" counter was filled to capacity. This may have resulted from the shift accumulator getting stuck in the "one" digit position and loading up all the binaries during operation of the shift register.

TABLE I

Micrometeorite Counter Readings, Pioneer V

Date 1960	Zebra Hour	Time Minute	"A"	"B"
11 March	13	25	045	7
14 March	22	40:35	045	7
14 March	22	41:11	127	7
20 March	18	15	127	7
20 March	22	32	000	7
27 March	17	15	000	7
29 March	13	40	001	7
29 March	17	01	003	7
2 April	12	41	006	6
3 April	12	47	007	6
14 April	22	49	007	7
18 April	15	30	127	7
24 April	--	--	127	7

No counts were recorded during the next six days. At 2232 on 20 March the "A" counter became unsaturated and changed to 000. Again no counts were recorded during the following seven days. On 29 March the "A" counter apparently began counting, but on 18 April the counters again went to saturation. Between 27 March and 29 March the experiment may have been working correctly; the impact rate was 1.5×10^{-3} impacts meters^{-2}sec^{-1} during this time.

On 2 April the "B" counter reading went to 6 with a corresponding change in the "A" count. A series of 13 to 15 consecutive "B" level counts or an effect from operation of the under voltage control may have caused this change.

Thus, there is evidence of faulty operation of the equipment associated with the micrometeorite experiment on Pioneer V. It is doubtful that any useful data will be forthcoming from the experiment. Perhaps some useful data may appear during the rest of the time of operation of the experiment.

The experiment was initiated at the Air Force Cambridge Research Center and later was made a cooperative experiment with NASA because of personnel transfers. The piezoelectric transducer was constructed by the Physics Department of Temple University and the amplifier and pulse discriminator which fed into the Space Technology Laboratory's telebit unit was supplied by the Oklahoma State University. Herbert A. Cohen and others carried out the work at the Air Force Cambridge Research Center. At NASA, W. Merle Alexander and Maurice Dubin worked on the experiment.

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STL MAGNETOMETER EXPERIMENT - PIONEER V

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The search coil magnetometer aboard the Pioneer V vehicle has continued to return data from the time of launch to the present. This is the most sensitive magnetometer which has been flown on any interplanetary mission and represents the first American magnetometer experiment in interplanetary space. Several results highly significant to geophysicists and astrophysicists have already been determined from examination of the data.

The first of these results is a confirmation of the perturbed field first noted on Explorer VI. The assumption that this perturbation is due to a hydromagnetic ring current circling the earth is consistent with examination of the data of both Explorer VI and Pioneer V. This then represents the first observation of a ring current phenomena whose existence has been argued for over a half century by geophysicists.

The second observation of importance made by Pioneer V was that an intense zone of disturbed magnetic field exists at distances of some 10 to 15 earth radii and that the interplanetary boundary of the earth's magnetic field is twice as far from the earth as has previously been supposed. A detailed observation of this region was first made by Pioneer I. Only partial release of that information was made at that time because of the strong desire to have a confirmatory flight. These disturbances appear to be waves in the highly ionized distant atmosphere of the earth. They also represent a class of phenomena which has been postulated by astrophysicists as existing at certain boundaries of cosmic gas clouds. This is the first experimental observation that such a process actually takes place. The observation on both Pioneer I and Pioneer V of a collapse of the geomagnetic field at distances greater than 13 earth radii represents a conflict with existing theory concerning the interaction of a solar wind with the geomagnetic field.

The third important set of observations made to date by the magnetometer aboard Pioneer V has been a detailed examination of the interplanetary magnetic field. Significant correlations with the cosmic ray experiments are in progress, particularly concerning the unusually intense solar storm which took place on March 31. In addition to this storm event, small fluctuations in the field which correlate with the cosmic ray experiments are being investigated for their possible significance in relation to the propagation of gas clouds through the interplanetary region. The repeated return, after storm events, of the magnetic field to the same value is perhaps indicative of a large-scale quiet time field in space. It is expected that these pioneering observations of the interplanetary magnetic field will, upon further study, shed new light upon the physical nature of the solar system.

RING CURRENT

Analysis of magnetometer data from the Explorer VI and Pioneer V has established the existence of a ring current which is circulating around the earth at an altitude of 10 earth radii. The existence of the current system has been detected by its effect on the extraterrestrial geomagnetic field.

At altitudes beyond 6 earth radii, the ring current causes the magnetic field measured by a satellite-borne magnetometer to depart markedly from that due to the geomagnetic field alone. These field deviations have been observed both by Explorer VI and Pioneer V. The two vehicles sampled two widely separated regions of space.

The quantitative agreement between these measurements indicates that the current system forms a giant ring which encloses the earth. The center of this ring current occurs at 10 earth radii and covers a region of space extending from approximately 7 to 13 earth radii.

The total current flowing inside this region of space has been computed to be 5 million amperes. The newly discovered ring current is not to be confused with the Van Allen radiation belts which occur at altitudes of about 1 to 6 earth radii. The latter are due to the trapping of high-energy particles in the earth's magnetic field. On the other hand, the ring current most probably consists of low-energy particles and consequently has gone unobserved by the high-energy detectors customarily used to investigate radiation particles.

- END -

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STL PAYLOAD ASSEMBLY AND COMMUNICATIONS RESPONSIBILITIES FOR PIONEER V

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Los Angeles, California

The integrated tracking, telemetry, and command radic communication link with Pioneer V has performed successfully since launch. The payload transmitter was acquired six minutes after launch and was turned off by the Manchester ground station 25 minutes later. In subsequent weeks the transmitter has been operated on a duty-cycle of about 10 per cent; for every hour of transmission time about 10 hours of battery recharging takes place.

Initial tracking data from the global Space Navigation Network proved to be very accurate and reliable, so much that the machine computation of the Pioneer V trajectory made 16 hours after lift-off has not required refinement since then.

Of the eight possible commands that can be transmitted to Pioneer V, six have been successfully executed. The first command, "Transmitter off," is of course sent at the close of every tracking exercise, which usually last about 30 minutes. The second command "Transmitter on at 64 pulses per second" was first sent by Florida immediately prior to liftoff. The third, "Separate payload from third stage" was sent by Manchester 25 minutes after liftoff.

To be able to concentrate the available power in Pioneer V on telemetry transmission, a variable rate at which information is transmitted was incorporated as a part of the design of the communication link. The Singapore ground station, because of its relatively small antenna, was the first to send the fourth command, "Transmitter on at 8 pulses per second." It did this at 0218 EST on March 12, when Pioneer V had reached a range of 150,000 miles. The Hawaii station dropped to 8 pps 15 hours later, but Manchester, with its very large 240-foot antenna did not have to drop to 8 pps until its tracking exercise at 0930 EST on March 20, when the payload was 1,313,000 miles out.

It was necessary to remove the Singapore and Florida stations from ground tracking on March 13 because of their small antennas. On March 17 at 2100 EST Hawaii transmitted the fifth command "Transmitter on at 1 pps," when the payload had reached 972,000 miles. It was not necessary for Manchester to send this command until 0620 EST April 16, when range had reached 4.8 million miles. Six hours later Manchester transmitted the sixth command, which altered the search frequency of the receiver in Pioneer V from 40 to 18 kc, its search time from 10 seconds to 3 minutes and its bandwidth from 250 to 40 cps. The effect of the command is to increase the sensitivity of the payload receiver by 10 db.

The remaining two commands are both concerned with operation of the 150-watt amplifier in Pioneer V. It will be necessary to send these commands when range has extended to 10 million miles or so, and because of the consequent more rapid power drain in the payload, reduce the transmitter duty cycle to 1 or 2 per cent.

The only difficulties in the communication link with Pioneer V have occurred in the ground stations. Transmitter repair caused the Hawaii station not to be able to function for a day and a half, and high winds at Manchester forced this station to be inoperative briefly. Payload equipment, however, is performing quite well, and forecasts now for continued reception out to the maximum range hoped for are quite optimistic.

- END -

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PIONEER V STATISTICS

Launch: 11 March 1960 8:00:07 EST

Altitude 78.1 degrees
Azimuth 92.9 degrees

Probe weight 94.8 pounds (26-inch spherical aluminum shell)

Burn Out Velocity: 24,886 miles per hour or 36,499 feet per second

Orbital Elements:
Period 312 days
Time to perihelion 152 days
Eccentricity .104
Inclination to ecliptic 3.35 degrees

Heliocentric Phenomena:
Perihelion 10 August 1960
Aphelion 13 January 1961

Distances:

At Perihelion....From Sun 74.9 million miles
From Earth 46 million miles
From Venus orbit 8 million miles
From Venus 140 millions miles

At Aphelion......From Sun 92.3 million miles
From Venus 131 million miles
From Earth 84 million miles
From Earth orbit 500,000 miles

Speeds:

At Perihelion.....78,000 miles per hour
At Aphelion.......63,300 miles per hour

Earth Mean Speed 66,593 miles per hour
Pioneer V Mean Speed 68,750 miles per hour
Venus Mean Speed 78,403 miles per hour

At 6.7 million miles for Earth:

Time about noon EDT, 29 April 1960
Velocity approximately 6,470 miles per hour
Time for signal to reach probe 36 seconds

Telemetry data as of 29 April 1960 - more than 100 hours of tapes.

Integration of the Pioneer V orbit has been carried out for the next 7.5 years, taking into account perturbations of the Earth-Moon system, Venus and Jupiter.

The probe will return to within 16 million statute miles of the Earth on November 6, 1965. The eccentricity of the Pioneer V orbit produces the oscillations superimposed on the basic variation shown in the following figures.

Because of these oscillations, a second close approach to the Earth occurs about April 1, 1966 at a distance of 15.6 million statute miles. Thereafter, the pattern will repeat roughly every 5.8 years (the synodic period) with each approach distance different from the last.

An approach to the Earth much closer than that of 1966 will not occur until 1989, when a fairly close approach should occur--less than two million miles.

The first close approach of the probe to Venus will occur September 28, 1961 at a distance of 22 million miles.

This table illustrates Earth-to-probe and Venus-to-probe distances at 40-day intervals for the next 7.5 years:

Calendar Date	Distance of Pioneer V from Earth (millions of Statute Miles)	Distance of Pioneer V from Venus (Millions of Statute Miles)
Apr 6, 1960	3.5	
May 16	9.4	149.4
Jun 25	21.8	145.5
Aug 4	43.0	141.7
Sep 13	65.8	143.7
Oct 23	81.2	148.1

Calendar Date	Distance of Pioneer V from Earth (Millions of Statute Miles)	Distance of Pioneer V from Venus (Millions of Statute Miles)
Dec 2	86.5	145.8
Jan 11, 1961	84.3	131.3
Feb 20	80.2	106.2
Apr 1	81.3	78.2
May 11	92.3	57.0
Jun 20	111.7	46.9
Jul 30	131.6	39.6
Sep 8	145.2	26.1
Oct 18	150.7	27.2
Nov 27	149.4	55.1
Jan 6, 1962	144.9	82.1
Feb 14	142.5	98.8
Mar 27	146.8	105.7
May 6	157.4	110.7
Jun 15	169.2	122.3
Jul 25	178.5	140.1
Sep 3	183.1	155.0
Oct 13	182.9	159.3
Nov 22	177.5	151.7
Jan 1, 1963	171.4	137.5
Feb 10	167.4	125.7
Mar 22	167.1	121.4
May 1	169.9	118.7
Jun 10	174.4	107.8
Jul 20	177.7	84.6
Aug 29	177.1	53.4

Calendar Date	Distance of Pioneer V from Earth (Millions of Statute Miles)	Distance of Pioneer V from Venus (Millions of Statute Miles)
Oct 8	171.2	25.0
Nov 17	160.7	15.5
Dec 27, 1963	148.0	21.9
Feb 5, 1964	137.3	31.1
Mar 16	132.6	49.7
Apr 25	133.7	78.4
Jun 4	136.3	108.2
Jul 14	135.7	129.9
Aug 23	128.6	139.5
Oct 2	113.8	140.0
Nov 11	93.5	139.0
Dec 21	74.8	143.4
Jan 30, 1965	64.9	151.6
Mar 11	64.1	154.9
Apr 20	67.0	146.5
May 30	67.2	126.7
Jul 9	60.1	102.1
Aug 18	43.9	82.6
Sep 27	23.5	73.3
Nov 6	16.0	66.7
Dec 16, 1965	20.7	52.0
Jan 24, 1966	20.5	30.4
Mar 6	16.7	31.5
Apr 15	16.2	55.6
May 25	25.3	74.3
Jul 4	44.0	83.5

Calendar Date	Distance of Pioneer V from Earth (Millions of Statute Miles)	Distance of Pioneer V from Venus (Millions of Statute Miles)
Aug 13	68.0	89.9
Sep 22	88.4	103.5
Nov 1	99.4	125.0
Dec 11	101.0	145.4
Jan 20, 1967	97.3	156.2
Mar 1	94.3	154.9
Apr 10	98.5	145.5
May 20	112.5	136.7
Jun 29	131.7	134.3
Aug 8	148.3	134.5

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Department of Physics and Astronomy
State University of Iowa

Progress Report on Investigations with State University of Iowa Apparatus on Explorer VII (1959 Iota)

I. Preliminary Results of Outer-Zone Investigations

The apparatus designed and built by the group at the State University of Iowa and placed on Explorer VII has been described in detail by Ludwig and Whelpley (Corpuscular Radiation Experiment of Satellite 1958 Iota, J.G.R. 65, pp. 1119-1124, 1960).

To date the data given particular attention have been those concerning the particle radiation in the vicinity of the outer radiation zone. The results are being analyzed in order to determine whether there are any diurnal variations in the position and intensity of the zone, in an effort to determine the detailed mechanism for the formation of this zone.

Detailed analysis has been made of the morphology of the changes wrought in the outer zone by several magnetic storms.

In one of these, that of 18 October 1959, it was found that several narrow zones of enhanced radiation were formed at latitudes below the outer zone. These gradually blurred over into a single broad zone of high-intensity trapped radiation, peaked at geomagnetic latitude around 56°, or 6° lower than the outer zone. This trapped radiation was almost totally gone within a day after the cessation of the storm.

As a contrast to the effects of the relatively minor magnetic storm of 18 October 1959 which did not particularly affect the outer zone itself, we have also studied the effects of the severe storm of 28 November 1959. The effects of this storm were firstly, to greatly deplete the intensity of trapped radiation at high latitudes beyond the peak of the outer zone. The outer zone was thus made much narrower, and it moved towards lower latitudes. Initially very intense fluxes were observed in the peak, and then these gradually disappeared so that on 29 November the counting rate of the 302 counter was only about one tenth that on 28 November. This effect was noted in both hemispheres.

Figure 1 shows counting rates as Explorer VII passed through the outer zone on 27, 28, 29 November. The zone was stable on 27 November, but very disturbed on the next day, when a 3-second wide peak at 0336.30 Z was over an auroral arc, as sketched in Figure 2. Furthermore, a monochromatic 6300Å sub-visible arc was under the outer zone throughout the night (Fig. 3).

It appears that the visible auroral arc may have been generated following a very rapid dumping out of trapped particles. Then over a period of many hours more particles were scattered out and these caused the sub-visible wide red arc.

If these interpretations are correct, these observations provide the first direct study of the transfer of energy from the outer radiation zone into auroral and airglow displays.

The most recent and thus far the most drastic observed modification of the outer zone occurred during the period 31 March to 10 April 1960. The time relationship to the very great magnetic storm which began on 31 March leaves very little doubt of the causal association with this event. For several weeks previous to the event the outer zone had been relatively stable in intensity and position. The intensity as observed with the lightly shielded 302 tube was about 200 counts per second. On 31 March-1 April the outer zone as observed at 1000 to 1100 km altitude almost completely disappeared, (less than 10 counts per second.) Wide-spread aurorae at low latitudes were reported, favoring the view that the trapped radiation was being precipitously dumped into the atmosphere by magnetic perturbation. The outer zone recovered rapidly in intensity (showing at times considerable detailed structure); by a week later the intensity had built up to over 10,000 counts per second. The intensity then gradually declined toward its pre-storm level.

A similar counter and an ionization chamber in the Minnesota apparatus in Pioneer V (at some 5×10^6 km from the earth) observed a very mild burst of increased counting rate of soft radiation (two or three times cosmic ray intensity) during 31 March. But at no time during the period 31 March- 7 April was any intensity of soft radiation within a factor of a thousand of our outer zone maximum observed. We conjecture (1) that the mild burst of activity which was observed by Winckler et al. on 31 March with Pioneer V represented the direct detection of the incoming plasma cloud, (2) that the energy distribution of particles in the cloud was such that it was detected with very low efficiency, (3) that a portion of this low energy plasma was injected into the geomagnetic field, modifying the field so that much of the trapped radiation then present was dumped into the atmosphere, and (4) that the great subsequent increase in observed outer zone intensity resulted from local acceleration of a portion of the particles in the trapped plasma to sufficiently high energy to be detected by our equipment.

2. Solar Protons

A continuous watch for solar protons is provided by the State University of Iowa equipment in Explorer VII at its most northerly and most southerly latitudes, whenever the outer zone is not sufficiently extended to mask them.

The following is a preliminary list of such cases from 13 October 1959 to date. The intensity is given as a ratio to cosmic ray intensity ($2.0/cm^2$ sec.) of protons of energy greater than 30 Mev.

Date	S.U.I. Pass No.	Intensity
30 November	191	0.4
17 March	771	0.4
17 March	772 (12:35-12:43 U.T.)	0.3
17 March	774	0.4
1 April	871 (10:18-10:28 U.T.)	30.
1 April	872 (12:03-12:09 U.T.)	7.
2 April	873	0.4
5 April	898 (07:06 U.T.)	0.3
5 April	899 (08:49)	2.0
5 April	900 (10:33)	2.0

In comparison with the I.G.Y. period 1957-58 it is seen that there has been a notable decrease in emission of energetic protons by the sun. The events of 30 November and 17 March were at the threshold of trustworthy detection. The events of 1, 2, 3 April and 5 April were prominent but were nonetheless small compared to a number of the events observed by various means during the I.G.Y. (including the August events detected by Explorer IV). Winckler et al. and Simpson et al. also detected these latter two events with Pioneer V. A preliminary comparison shows all available observations to be in good agreement in time and in intensity. The Explorer VII observations of intensity as a function of latitude will provide a good energy spectrum. The solar flare which yielded the protons was well observed by optical and radio means, (onset 0845 on 1 April).

3. Forbush Decreases

Two Forbush decreases in cosmic ray intensity have been noted:

Date	S.U.I. Pass No.	Amt. of Decrease
4 December	276	25%
1 April	869	20%
1 April	870 (08:30-08:43 U.T)	25%

Thereafter masked by solar protons.

The latter event was also observed by Pioneer V.

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SOLAR COSMIC RAYS AND SOFT RADIATION OBSERVED AT 5,000,000 KM FROM EARTH

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During the period March 27 to April 6, 1960, the integrating ionization chamber and Geiger counter in the space probe, Pioneer V, detected solar cosmic rays and some soft radiation effects associated with a high level of solar activity. At this time the space probe was about 5,000,000 km from the earth, approximately in the plane of the ecliptic and located somewhat behind the sun-earth radius toward the sun. The solar activity was associated with plage region H-15[1] which crossed the central solar meridian on April 1, 1960. The region was characterized by numerous flares of all sizes, large loops and surge prominences, and strong solar radio emission over a wide range of frequencies. On March 31st at 0800 UT, a severe geomagnetic storm began on the earth accompanied by major earth current disturbances, the complete blackout of the North Atlantic communications channel, and auroral displays. Also at this time, a large Forbush decrease occurred in the galactic cosmic radiation. An intense series of balloon flights was made at Minneapolis during the period and various counting rate increases were observed at high altitude. The earth satellite, Explorer VII, showed very substantial changes in the earth radiation belts and gave evidence also for the solar cosmic rays.

The records of the instruments on Pioneer V on the basis of preliminary data are shown in Figure 1. Following launch on March 11th, as the payload passed through the outer radiation belts, the radiation levels rapidly dropped to the galactic cosmic ray background rate which was maintained with minor fluctuations for the first two weeks on the ion chamber and Geiger counter. Then a sequence of solar flares began, following the appearance of the region H-15 on the visible disk. Those of class 2 or larger are marked on the base line of the figure. In five or possibly six cases these flares produced a response of the instruments within a few hours which can be identified as low energy solar cosmic rays of the type observed previously on many occasions and reported in the literature(2). For the first time, we have now observed these solar cosmic rays in space completely free of the environment of the earth. The largest cosmic ray bursts occurred on April 1st, associated with a class 3+ flare beginning at 0830 UT, and on April 5th, associated with a major radio disturbance and with a flare probably present but not so far identified. These cosmic ray accelerations have the following properties:

1. The sizes range from just detectible above galactic cosmic ray background(3/27 and 28)to particle fluxes 10 times galactic background.

2. The observed ion/count ratio of 7 to 10 inside 0.5 to 5 g/cm^2 of shielding is consistent with a differential energy

spectrum of the form $N(E) - CE^{-4}$ with a lower spectrum limit of about 40 Mev.

3. The decrease of the particles in space, timed from the optical flare in the two large bursts, follows the law $I - I_0 T^{-1.9}$. The decay seems definitely more rapid than the 1.5 power law associated with simple diffusion.

4. Balloon flight M-38 at Minneapolis on April 1, 1960, during the large flare showed the presence of solar protons of energy up to 400 Mev and with a flux and spectrum consistent with the space probe results. This balloon flight occurred during a severe magnetic disturbance from a previous flare.

5. Three of the cosmic ray events produced polar ionospheric changes ("Polar Blackouts" - see Figure 1) reported by Leinbach at College, Alaska(3).

6. Two of the cosmic ray events were detected by the counters on satellite Explorer VII(4). The particle fluxes when compared with the space probe are in good agreement.

7. Although the events have been analyzed on the basis of a proton flux alone, the presence of a smaller flux of a-particles cannot be excluded.

In Figure 1 we have plotted (below) the galactic cosmic ray intensity as measured by balloon ion chambers at Minneapolis and by a sea level neutron monitor (Deep River, Canada, courtesy Hugh Carmichael)(5). A large Forbush decrease occurred on March 31 - April 1. The decrease at sea level at high altitude was 10% and in balloon ionization was 25%. The exact ratio for the decrease of balloon ions/neutrons is 2.3. Since it is necessary to know the base line of the space probe instruments to evaluate the nature of the increased rates, we have normalized the balloon and space probe ion chamber during the first two weeks of Pioneer V flight. The base lines through the disturbed period in Pioneer V were then constructed using the balloon ion chamber results. This should be an accurate procedure as the primary cosmic ray spectrum at present includes negligible radiation not seen at the latitude of Minneapolis.

On March 31 and again on April 4, the high ion/count ratio gave evidence for soft bremsstrahlung radiation from electrons striking the Pioneer V payload. The intensity in the ion chamber was at most 2.5 milliroentgens/hr, which corresponds to an electron flux of less than $10^6/cm^2 \cdot sec$ at 50 kev.

During the period April 2-7, and following an initial "dumping" on April 1, the outer radiation belt of the earth increased in intensity from 10 to 40 times normal at ranges of 1000 km above the surface. These observations were made by J. A. Van Allen and the SUI group[(6)]. We have reported a very similar behavior of the outer zone during a magnetic storm observed with Explorer VI on August 17-19, 1959[(7)]. In that case, the peak ionization chamber reading in Explorer VI at 23,000 km near the equator was 30 r/hr or 20 r/hr higher than "normal".

We can now say conclusively that the great increase in 50-kev electrons observed by Van Allen et al in the outer zone on April 2-7 was not due to direct solar injection, as the flux observed by Pioneer V in space was only 10^{-4} of that appearing in the outer zone. It seems likely that the weak electron flux observed in Pioneer V on March 31 and April 4 represents the high energy end of a solar plasma cloud spectrum associated with the magnetic storm and Forbush event. We conclude that a local acceleration of a portion of this plasma in the magnetic field of the earth builds up the outer radiation zone.

Minneapolis, Minnesota
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